The Development of Games-Based Learning Media in Terms of Students' Mathematical Reasoning

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Abstract: The research aimed to know the result of validity, practicality, and effectiveness of products from the development of games-based learning media in terms of students' mathematical reasoning on three-dimensional shapes. The type of research and development referred to ADDIE model which included five stages, namely analysis, design, development, implementation, and evaluation. The subjects of the research were the 25 VIII grades junior high school students in one of the junior high schools in Indonesia. The research instruments used were the validation questionnaire sheets, teacher responses questionnaire, and student responses questionnaire. The data collection used a Likert scale. Furthermore, the effectiveness data were collected from the post-test that was done by the student through learning media to know their mathematical reasoning abilities. Meanwhile, the data analysis technique used quantitative descriptive analysis. The result showed that media was very valid with an average of 91,86%. Moreover, it was very practical to see from the average of teacher response questionnaire which was 89,58%, and the average of student responses questionnaire which was 85,36%. The value of effectiveness was determined based on students' post-test scores which was 84%. Thus, it can be concluded that this media was effective to be applied as a learning media for junior high school.

Keywords: Blended learning, Learning media, Mathematical reasoning

Introduction

The development of technology and information, in the 21st century, required the education system to adapt by integrating technology into the learning process. It is useful for improving the education quality under student characteristics in the current era. According to Purmadi et al. (2018), a learning model or media success depended on student characteristics. Today's, students have strong characteristics and interact through social media. They are very fluent in the use of technology, expressive, and always following global trends (Yanasari, 2021).

Learning activity that combines technological development and conventional learning is called blended learning. According to Rusman et al. (2012) blended learning is a combination of blended e-learning aspects in the form of web-based instruction, video streaming, audio, synchronous and asynchronous communication with face-to-face learning including teaching methods, theory, and pedagogic dimensions. This learning design provides the opportunity to learn with various learning sources to create a more effective learning environment for teachers and students. Sutopo (2012) said blended learning is a learning method that combines various methods and learning media.

Sharma (2010) described blended learning in 3 definitions, namely as a combination of face-to-face and online learning, a combination of technology, and a combination of teaching methods. The combination of face-to-face and online learning is a combination of traditional learning with online learning through technology or computer-based learning, such as involving a Virtual Learning Environment (VLE) and using synchronous and asynchronous electronic tools.

Furthermore, a combination of technologies means that the learning activity uses technology to overcome the limitations of space and time, especially in communication between teacher and student. Through blended learning, we can achieve the learning objectives maximally with more interactive, effective, and efficient learning. Sutopo (2012) said blended learning improves the quality and quantity of human interaction in the learning environment. The computer used in learning activities makes students and teachers interact more easily whenever and wherever they are. Then, a combination of methodologies means that the teacher combines several pedagogic approaches, for example involving transmission and constructivist approaches (Sharma, 2010).

Based on the description above, it can be concluded that blended learning is a learning design that combines learning aspects of face-to-face learning and online learning in the form of media, technologies, and learning approaches. Blended learning is structured by paying attention to the advantages of face-to-face learning and e-learning. In addition, according to Rusman et al. (2012), the advantages of blended learning include: (a) increasing the interaction between students, teachers, and instructors in learning activity; (b) enabling learning to occur anywhere and anytime; (c) reaching students in a wider range; (d) easy to refine and keep the learning materials.

Now, mathematics and technology are an inseparable part of our lives. 45% of the world's population accessed the internet for mobility activity, online courses, and massive open online courses (Borba et al., 2016). There has been a significant increase with a database of statista.com which showed that 64,4% of the world's population accessed the internet in January 2023. Based on data from Badan Pusat Statistik (BPS) for 2021, there were about 12,07% of Indonesian citizens used computers and 65,87% of Indonesian citizens used smartphones. In addition, based on the result of the Asosiasi Penyelenggara Jasa Internet Indonesia (APJII) survey, in early 2023 the internet user in Indonesia reached 78,19%. These data showed that technology and the

internet are a necessity for people to facilitate their work, communicate, have fun, and learn.

Meanwhile, mathematics is a universal science that has an important role in human life, especially in technology development. Mathematics is also a science that provides provisions for humans to be able to face challenges in the era of globalization. Mashuri (2019) said that mathematics is useful for developing someone's intellect and as a fundamental science for the development of modern technological science. Mathematics equips students with logical thinking, analytical, systematic, critical, and creative thinking abilities so that students can solve the problems that they face in daily life.

(Hasanah et al., 2019) said students can develop themselves by practicing their abilities continuously through mathematics. Therefore, mathematics is a compulsory subject from elementary school to high school. It also shows that the integration of technology and mathematics is very influential in daily life. However, many students do not like mathematics because of the difficulty in mathematical reasoning to solve problems. As mentioned by Istikomah & Wahyuni (2018), the students do not like mathematics because they assume mathematics is an unpleasant subject, difficult to understand, and has difficult tasks and problems.

Mathematical understanding and mathematical reasoning are two things that cannot be separated. According to Hasanah et al. (2019) to understand mathematics, students need to reason, while reasoning is understanding and practicing mathematics. Students who have good reasoning skills can understand mathematical concepts more easily.

Mathematical reasoning means that someone carries out a process of logical thinking so that they can understand, think, prove, and evaluate mathematics. Mathematical reasoning is a thinking process that combines two or more thoughts to produce conclusions to create new knowledge (Hasanah et al., 2019). Reasoning ability is needed for solving mathematical problems during the process of understanding, planning the problem solving, solving the problems, and making the conclusion. In line with Bernard & Chotimah (2018) said that solving mathematical problems must involve reasoning. According to Bukhori (2018), the indicators of mathematical reasoning are finding patterns, formulating mathematical conjectures, and drawing conclusions based on valid arguments.

According to Abidin et al. (2020) one of the reasons students have difficulty in reasoning was that students are not given problems to develop their ability to guess, think logically, and draw conclusions from information. The given mathematics learning design presented material from the concepts, not from problems that may be encountered by students in their daily lives. Giving daily problems can develop students' ability to think logically, inductively, and deductively. Therefore, teachers need to make appropriate learning designs to support students' mathematical reasoning abilities. According to Bernard & Chotimah (2018), one of the factors that greatly influences students' mathematical abilities is the quality of learning mathematics.

One of the determining factors for the quality of learning is the selection of learning media. The learning media used must be able to connect the knowledge possessed by students in real situations with learning materials. In addition, the learning media should be adapted to current technological development. According to Abidin et al. (2020), learning media must facilitate students to think critically, creatively, and innovatively.

Based on the result of interviews with one of the mathematics teachers in one of the junior high schools in Indonesia, the teacher had never tried to use learning media that integrated with technology. The teacher conveyed abstract subjects by visualizing them through sketching on the blackboard. However, students still have difficulties in doing mathematical reasoning and lack the motivation in learning mathematics. Students have difficulty to imagining the elements needed to determine the surface area and volume of the 3D shapes. In addition, students also used the memorization method, so they found it difficult to do mathematical reasoning. The learning activity in the classroom also shows a lack of interaction between students and teachers, students and students, as well as students and the learning resources.

Digital games are used as effective media to improve students' mathematical reasoning abilities. Jensen & Skott (2022) said that digital games support the exploration of mathematical relationships, the framework that supports students' conjecturing and justification, as well as comparing and discussing different results from a game with other students. Digital games can support students' mathematical reasoning if the games present tasks that can bring up their discoveries about the mathematical relationships in the game. Moreover, the interaction in learning activities in the classroom must occur properly.

Several studies related to the use of game-based learning media in mathematics learning have been carried out and gave had a positive impact. Kartika et al. (2019), Saputro et al. (2018), and Rofiqoh et al. (2020) developed game-based learning media that can be played on computer devices. These studies show the same results, namely game-based learning media can facilitate students in learning mathematics, provide varied learning so students do not feel bored, and increase student motivation. Furthermore, interaction in learning activity was increased because students interact directly with learning resources and discuss with other students (Jensen & Skott, 2022; Kartika et al., 2019).

Based on the studies above, media development only focuses on evaluating game-based learning and is not equipped with material explanations. However, the games did not use the unlock-level system. The unlock level system can provide challenges to students to complete levels to foster students' competitive spirit. In this study, the games will be equipped with a level-unlock system and the effectiveness of media will assess in terms of mathematical reasoning.

Based on the description above, the title of this research is **The Development of Games-Based Learning Media in Terms of Students' Mathematical Reasoning**. The purpose of this study is to determine the result of validity, practicality, and effectiveness of games-based learning media in terms of students' mathematical

reasoning. This media is expected to help students understand the concept of mathematical material so that they can do mathematical reasoning properly and correctly. Furthermore, it is also hoped that his media can increase students' motivation in learning mathematics and make learning activities more interactive.

Method

The Type of Research

The type of this research was Research and Development (R&D) which referred to ADDIE model which contains 5 stages, namely Analyze, Design, Develop, Implement, and Evaluate. ADDIE model is a well-adapted model, flexible, and effective, and also provides a structured general framework (Angko & Mustaji, 2013). Moreover, the ADDIE model has evaluation and revision at each step. The research object was game-based learning media on the flat side 3D shapes subject for VIII grades. The subjects of this research were the 25 VIII grades junior high school students in one of the junior high schools in Indonesia.

The instruments of this research were the questionnaire sheets and the test in learning media. There were three questionnaire sheets, namely the validity questionnaire sheet to measure the validity of media, the student responses, and the teacher response questionnaire sheets to measure the media's practicality. The data of validation and practicality of media were collected by using the Likert scale. Meanwhile, the effectiveness data were collected from the post-test that was done by the students through learning media. Then, the data analysis used a quantitative descriptive analysis technique.

The learning media was validated with 3 assessment aspects, namely media display, contents, and language aspects. The media was validated by 3 validators. According to (Akbar, 2013) the formula for measuring the result of validity is:

$$V = \frac{Tse}{Tsh} \times 100\%$$

Description:

V   = The validity score

Tse = The empirical total score

Tsh = The maximum expected total score

Next, the validity score was connected with the validity criteria of learning media. According to Riduwan (Hidayati & Susanti, 2013), the validity criteria of learning media can be seen in Table 1.

Table 1. The Validity Criteria of Learning Media

Validity Score	Validity Criteria
76% - 100%	Very valid

51% - 75%	Valid
26% - 50%	Invalid
0% - 25%	Very invalid

Meanwhile, the practicality test aimed to know that media is practical to use and easy to understand so that students can understand the subjects and help teachers to deliver the subjects easily (Risnawati et al., 2019). According to Akbar (2013), the formula for measuring the result of practicality is:

$$P = \frac{Tse}{Tsh} \times 100\%$$

Description:

P = The practical score

Tse = The empirical total score

Tsh = The maximum expected total score

Then, the percentage of practicality was matched to the practicality criteria of learning media. According to Akbar (2013), the practicality criteria of learning media can be seen in Table 2.

Table 2. Practicality Criteria of Learning Media

Practicality Score	Practicality Criteria
75,01% - 100%	Very practical
50,01% - 75%	Practical
25,01% - 50%	Less practical
00,00% - 25%	Cannot be used

Furthermore, the data from the students' tests were used to measure the effectiveness of learning media. The result of the test that was done by students showed students' mathematical reasoning abilities. The score that showed that students pass the test was 75. So, the learning media was effective if 75% of the total students pass the test. The percentage of effectiveness of learning media can be found by formulas:

$$E = \frac{the\ number\ of\ students\ who\ pass\ the\ test}{the\ number\ of\ students\ who\ join\ the\ test} \times 100\%$$

Results

The product of this research was games-based learning media on the flat side 3D shapes subject for VIII grade students. The media can be run on a computer. The media was an interactive multimedia that provide game-based learning evaluation. Mathematics learning in the media was designed to support students' mathematical

reasoning abilities. The development of games-based learning media in this research referred to ADDIE model.

In the first stages, the researcher analyzed the needs of teachers and students. The data were obtained from interviews with one of the mathematics teachers in one of Indonesia's junior high schools. The topics of the interview were about mathematics subjects being studied, the media used, and student characteristics. The result of the analysis stage showed that the 3D shapes were abstract subjects. Students have difficulty understanding the subjects because they have obstacles in reasoning to solve problems in this subject. Then, learning activities also needed media that can increase students' learning motivation to create an interactive learning environment.

In the next stages, the researcher designed the learning media. The necessary research instruments, such as the validity questionnaire, teacher and student response questionnaire, and test, were also made. The initial step taken was to arrange learning material to be presented in the learning media. The subject was 3D shapes which consists of 4 meetings, namely the areas of prism and pyramid as well as the volumes of prism and pyramid. Then, the researcher created the media prototypes. The design of the media display consists of the homepage, instruction page, subjects page, evaluation page, and researcher profile (see Figure 1). The evaluation page is a feature for students who conducted games-based tests independently. The games used a level unlock system where a higher level will be unlocked and can be played if students pass the previous level. If students fail at a level, students need to study again and repeat the evaluation.

Figure 1. The Learning Media Design

After that, the media was produced using Construct 2 software. The media production involved navigation button production and combined some text, images, animation, and audio. Then, the products of learning media were validated by 3 experts. The result of the media validity analysis was very valid with a percentage of 91,86% (see Table 3).

Table 3. The Result of Learning Media Validity

Media	Assessment (%)			Average (%)	Validity Criteria
	V_1	V_2	V_3		
1st meeting	85,23	93,18	98,86	92,42	Very valid
2nd meeting	85,23	90,91	98,86	91,67	Very valid
3rd meeting	85,23	89,77	98,86	91,29	Very valid
4th meeting	85,23	92,05	98,86	92,05	Very valid
Average				91,86	Very valid

Then, valid media can be tested at the implementation stage. Media was tested on 25 students in VIII grades in one of the junior high schools in Indonesia for 4 meetings. Students used the learning media for independent learning. Students played games when they carried out learning evaluations through media. At the last meeting, the students and teacher were given the students and teacher response questionnaires. Then, data from questionnaires were analyzed to determine the practicality of media. Table 4 shows the result of media practicality.

Table 4. The Result of Learning Media Practicality

Respondents	Average (100%)	Practicality Criteria
Teacher	89,58	Very practical
Peserta Didik	85,36	Very practical

Based on Table 4 we know that the average teacher response questionnaire was 89,58% with very practical criteria. In addition, the average of student responses questionnaires was 85,36% with very practical criteria. At this point, students found it difficult to understand the language used in media.

Meanwhile, the result of the student's test was used to determine the effectiveness of games-based learning media. The percentage of effective media was 84% so the games-based learning media was effective. That result also showed that the students' mathematics reasoning abilities were good.

At the evaluation stage, the media was revised based on the advice of experts. On the aspect of the media display, the media was revised in the layout section and color composition. In addition, some of the navigation buttons also need to be repaired because they do not work properly. On the content aspect, the validator suggested writing the units of length at the solution of the example problems so that the units of the area in the

conclusion can be identified.

Discussion

The games-based learning media on the flat side 3D shapes for VIII grade students was the product of this research and development. The media was developed using the ADDIE model that consists of 5 stages, namely analyze, design, develop, implement, and evaluate. The result of the analysis stage showed that teachers and students need learning media that can help students understand the subjects easily. This media is expected to create interactive learning and can be used in blended learning.

The learning material was prepared before creating a media prototype. As Herlina et al. (2021) mentioned the material was prepared concerning core competencies, basic competencies, competency achievement indicators, and learning objectives. Thus, the games-based learning media are not only a tool because the media created with reference to learning objectives can be used effectively to improve the quality of learning.

The researcher produced media using Construct 2 software and it was quite easy to do. As Ridoi (2018) mentioned, this software has provided events and actions, behaviors, and various effects that can be used so that the projects can work properly. The user also does not need to know programming languages to create the media.

The result of validity was 91,86% which indicated that the games-based learning media was very valid. Moreover, the percentage of teacher response questionnaires was 89,58% and the percentage of student response questionnaires was 85,36%. It showed that the games-based learning media was very practical. Meanwhile, 80% of students passed the test. It means the games-based learning media was effectively used to help students learn 3D shapes subject. The media also can increase students' enthusiasm and interest.

According to students, learning activity using the media was fun because they played games for doing the test. An interactive learning process also occurred because apart from interacting directly with learning media, students also interacted with each other to get better learning outcomes. Jensen & Skott (2022) also said games can support students to experiment and explore when solving problems. This underlies the interaction and represents students' mathematical reasoning abilities.

Conclusion

Based on the result and discussion of the research, it can be concluded that the development of games-based learning media has tested its validity, practicality, and effectiveness. The learning media can be used to help teachers deliver subjects so that students can understand the subjects easily. The use of learning media allowed students to experiment, explore, and interact. It had an impact on students' mathematical reasoning abilities. So,

students can solve problems and achieve good learning outcomes.

Recommendations

The advice for further research is to create an online scoring system so that student scores can be recorded directly into the teacher's database.

Acknowledgments

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