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The use of game-based educational entertainment media to foster mathematical problem-solving proficiency in pre-service mathematics teachers

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ABSTRACT

The capacity to solve mathematical problems is an essential component of the professional abilities that pre-service instructors of mathematics are required to possess. When it comes to coping with technological advancements in the sphere of education, this skill serves as the foundation. For the purpose of enhancing one's capacity to solve mathematical problems, this study proposes an innovative method that involves the use of game-based educational entertainment media (GEM). Within the realm of development research, this research technique focuses on the ways in which problem-solving skills can be enhanced by participation in activities that are based on game-based entertainment media. The ADDIE phases—analysis, design, development, implementation, and evaluation—are the steps that are utilised in the process of development. The GEM was utilised by 94 pre-service mathematics teachers who participated in this research. GEM is effective in developing mathematical problem-solving skills, according to the findings of the research. This is accomplished by encouraging pre-service mathematics teachers to identify problems, model them, solve problems mathematically, and assess the results of their efforts.

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Introduction

The capacity to solve mathematical problems can be defined as a cognitive process that is shaped by factors such as the desired outcomes, the method of problem-solving, foundational abilities, and mathematical reasoning capability. Multiple authorities assert that mathematical problem-solving ability is associated with a person's capacity to deduce a mathematical solution to a given dilemma. (Blum & Niss, 1991; Hart, 1993). A similar opinion was also expressed by (Xenofontos, 2007), who concluded that "*problem solving ability*" has a different meaning for each person, such as being a goal, process, basic skill, mode of inquiry, mathematical thinking, and teaching approach. Thus, it can be concluded that mathematical problem-solving ability is a key competency that is very important in achieving successful mathematics learning.

Mathematical problem-solving ability is one of the cognitive competencies that can be trained or improved (Kretzschmar & Süß, 2015). Mathematical problem-solving abilities can be improved through a learning process that presents a problem-based approach. In line with (Education, 2005), which state that "*solving problems is a way of teaching,"* This statement reveals that problem solving is one way of teaching. As an alternative to teaching,

this does not mean that the information transfer process is carried out by presenting various problems in the form of story questions. However, also pay attention to instructions, techniques, and situations that can encourage students to discover and understand mathematical material in the process.

Several experts have identified dimensions or aspects that can be used to measure problem-solving abilities. (Bell & Polya, 1945) classified the dimensions of problem-solving abilities into the following four phases:

1. Identifying Problem

   This phase is an important phase that needs to be passed well before individuals find a solution. When understanding is misguided, then the next steps will be wrong. On the other hand, if the problem presented is well understood, then the chances of getting the right solution are much greater.

2. Modelling

   After understanding the problem, the next step is how individuals can develop a plan or strategy. Based on the knowledge and experience possessed by individuals, the strategies prepared can differ from one another. A good strategy is one that leads to finding the right solution.

3. Solve problems.

   The plans that have been prepared are then implemented to find a solution. This phase depends on the procedures carried out, and errors can occur if there are misconceptions about the processes carried out.

4. Evaluate

   After a solution is found, the next phase is to draw a conclusion. In this phase, it is necessary to review the resulting problems and look at existing solutions. To review whether the solution provided is appropriate or not.

(Atuahene-Gima, 2003) identified that problem-solving abilities are divided into three dimensions: (1) finding solutions; (2) quality of the solution; and (3) speed of resolving the problem. These three dimensions can be interpreted in mathematics learning. First, problem-solving ability is an ability related to how much effort a person puts into finding solutions to mathematical problems. Second, problem-solving ability is not seen as a process that emphasizes the results obtained. However, review more deeply how the strategies, methods, procedures, and mathematical steps were developed. Third, problem-solving ability is related to speed in solving mathematical problems.

Existing technological sophistication needs to be maximized to develop innovative and creative mathematical learning media. Innovative learning media will also create innovative learning activities (Aksakal, 2015). Furthermore, innovative learning activities will lead to what students will gain through what they do, not what students will receive from what the lecturer gives. Apart from demands for higher-quality education, the integration of technology in the lecture process and online learning conditions due to the impact of COVID-19 are also things that need to be considered in developing innovative learning media. Online learning, apart from requiring the integration of technology, also demands effective learning activities. This is because in the online learning process, students tend to understand the material independently, so media is needed that helps students understand the lecture material in depth.

Basically, lecturers are aware that integrating technology into teaching will have a positive effect (Allsop & Jessel, 2015). However, in fact, the technology-based learning media used are still relatively lacking in variety and novelty. According to the results of a survey of 125 active students in the Mathematics Department at UIN Walisongo Semarang, 77.6% had used learning media in the form of books or modules, 40.5% had used worksheets, 95.2% had used slide presentations, 20.8% had used teaching aids, and 0.8% had used application-based learning media. The survey results explicitly show that the majority of learning media used in the lecture process are books, modules, and presentation slides. This condition is in contradiction with students' desires for innovative and creative use of media in the lecture process. Of the 125 students, 47.2% had the perception that Android-based game media could be used as an innovative learning medium. Meanwhile, another 24.8% chose 3D-based simulation media and 27.2% chose AR-based e-books.

In this research, researchers tried to make a new breakthrough by developing game-based edutainment media (GEM) that can be used on PCs or smartphones (Android). Games are an activity that is liked by several groups, both children and adults. Survey results show that Indonesia is the country with the highest number of game users compared to several other ASEAN countries (newzoo, 2017). On a smaller scale, it also shows that 80% of the 125 students actually like playing games. However, games as a learning medium are still very limited, especially in higher-level education and teaching. The massive number of games in Indonesia has the potential to be used as a medium for learning mathematics.

Well-organized game activities can be an innovative medium for learning mathematics (McLaren et al., 2017). Based on its characteristics, games have a higher chance than other learning media in binding student interest in learning (Sudarmilah et al., 2013). Apart from the aspect of interest, game-based learning media can provide a meaningful learning process for students. Students will carry out a series of fun activities to gain an understanding of the material being studied. A good understanding, in the end, contribute to students having the ability to think mathematically at a higher level, one of which is the ability to solve mathematical problems. Students can understand the learning material, not only emphasizing how much effort the lecturer/teacher makes to explain the material. However, through meaningful self-study activities. A well-designed edutainment game media can certainly facilitate meaningful learning activities (RE, 2004). Meaningful learning has a close relationship with improving mathematical problem-solving abilities (Jana & Fahmawati, 2020).

Pre-service mathematics teachers need to have good mathematical problem-solving skills as a requirement for teachers' professional competence. Problem-solving ability as a thinking bridge between the world of mathematics and the real world. Therefore, problem-solving ability is a main competency that needs to be emphasized in achieving successful mathematics learning. Through GEM, prospective mathematics teachers will not only be equipped with good mathematical problem-solving abilities but will also receive preferences for innovative mathematics learning media. After using GEM, prospective mathematics teachers can feel how each stage of problem-solving ability is presented in activities on GEM. This research not only aims to see the feasibility of GEM in improving mathematical problem-solving abilities but also provides experience for prospective mathematics teachers in creating technology-based mathematics learning media that can be used and considered in the future. This research aims to answer how to promote mathematical problem-solving abilities through game-based entertainment media.

Method

This research is development research to produce GEM, which can improve the mathematical problem-solving abilities of pre-service mathematics teachers. This research involved 94 pre-service mathematics teachers as test subjects and primary data sources. The development model useded from the ADDIE model (Branch & Kopcha, 2014). The ADDIE model contains the following five stages of development: analysis, design, development. Implementation, and evaluation. The framework of this research can be seen in figure 1.

The GEM developed in this research is a game that contains three main elements: (1) stimulus, which contains initial problems or activities that generate prior knowledge; (2) strategy guided, which is related to instructions or keywords that can be used in developing strategies for solving mathematical problems; and (3) feedback, which helps users evaluate the solutions that have been found.

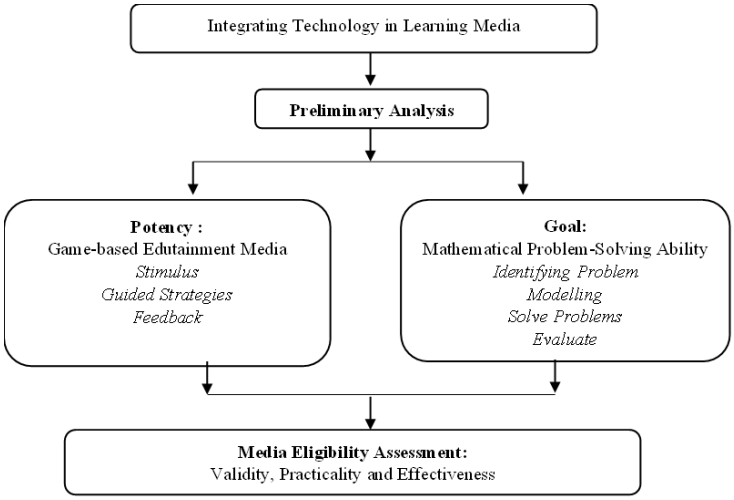

Figure 1 <Research Framework>

The main result of this development research is to produce an GEM to improve mathematical problem-solving skills for pre-service mathematics teachers which are developed through the following procedures: preliminary analysis, design, product development, implementation, and evaluation.

In this study, GEM was developed using Construct 3 software. Construct 3 is a game engine that is used to build games or applications that are suitable for several platforms. Games that have been created through the

Construct 3 program will be distributed to platforms, especially Smartphone (Android), Windows, Mac, and Linux. The concept of developing BM adventure can be seen in Figure 2.

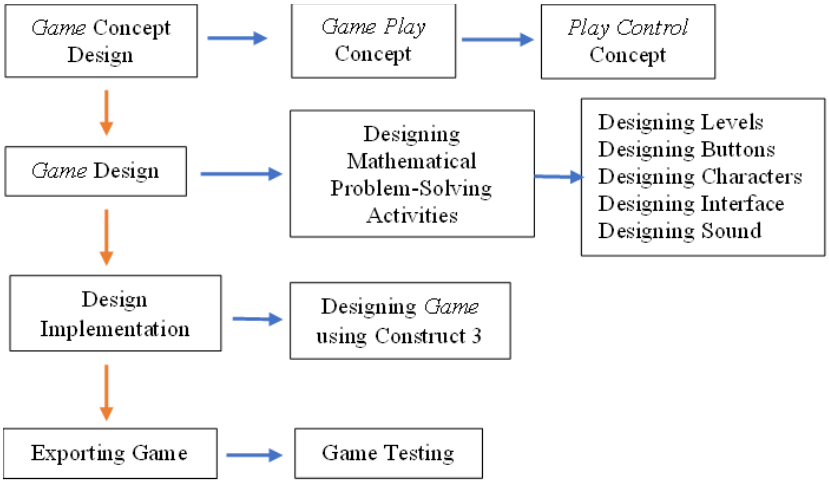

Figure 2 <Game Design Flowchart>

The development of game-based entertainment media (GEM) pays attention to how mathematical problem-solving abilities can be sharpened. The connection between activities in GEM and mathematical problem-solving abilities can be seen in figure 3.

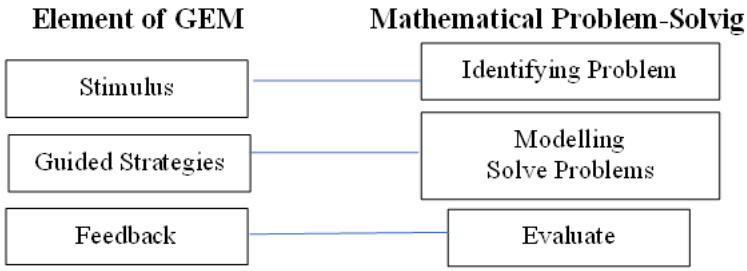

Figure 3 <Connection GEM Activites and Mathematical Problem-Solving>

At the stimulus stage, GEM presents prerequisite material that students need to have as capital for understanding and solving problems. For example, to solve mathematical logic problems, students need to understand what open and closed questions are. The activity shown in Figure 4 invites students to remember what an close question is.

Figure 4 <Stimulus in GEM Activites>

Furthermore, GEM improves the ability to formulate problem-solving strategies by presenting several guided discovery activities. The goal is for users to be fully involved in building concepts and then applying them to solve similar problems or different situations. Every activity in GEM is equipped with feedback, such as drawing conclusions from the problems encountered as well as evaluating user conclusions. This feedback aims to help users evaluate the results of problem-solving. The design of GEM is systematically developed to produce decent

game media (meeting the criteria of validity, practicality, and effectiveness). The design starts from the game concept design stage, game design, implementation, and exporting to get the game in APK form.

Results and Discussions

The media developed in this study was carried out through five stages of ADDIE development (Branch & Kopcha, 2014). The ADDIE stages in this study started from the preliminary analysis stage, design, development, implementation, and evaluation.

Analysis. Preliminary analysis is carried out by analyzing four categories, namely; (1) situation analysis; (2) needs analysis; (3) curriculum analysis; and (4) technology analysis. The results of a survey of 125 active students of the Mathematics Department, 77.6% have used learning media in the form of books or modules, 40.5% have used worksheets, 95.2% have used slide presentations, 20.8% have used teaching aids, and 0.8% have used application- based learning media. The survey results explicitly show that the majority of learning media used in the learning process are books, modules, and presentation slides. This condition contradicts the demands of students to use innovative and creative media in the learning process. Out of 125 students, 47.2% have the perception that Android-based game media allows them to be used as innovative learning media. Meanwhile, another 24.8% chose 3D-based simulation media and 27.2% chose AR-based E-books.

Design. At this stage, the researcher carries out activities related to preparing and designing the design of the Android-based edutainment game that will be developed. There are 3 activities at this stage: introduction, design draft, and material. First, it has been determined that the type of game to be made is an adventure, because it was easier to insert material that needs to be adapted to the game's storyline. Then, determined a few things such as game characters, game storylines, create flow charts and storyboards. Last, material preparation is carried out such as logic material, images, animations, and sound effects.

Development. The product development stage is the process of making the design that has been made into a unified whole, which is called the BM adventure game. The product development phase includes production, evaluation, and revision. 1) Production. The edutainment game media was developed using Construct 3 and will then be distributed to students. At this stage, the Android-based edutainment game media has been completed. Media can be used on Android smartphones (minimum version 5.1 Lollipop) and can be used on PCs with Windows, Linux, and Mac systems. The media has been exported into APK form with a size of 22 MB.

Figure 5 <Main Menu Display>

Evaluation. After the media is developed, the next step is formative evaluation activities. This formative evaluation was conducted to determine the level of validity of the BM adventure game media and the level of quality of the Logic material presented on the media. There are several stages in the evaluation stage: 1) Review by Expert. The BM adventure game is formatively evaluated by media experts. This evaluation is intended to determine the lack and level of feasibility in terms of media validity. Evaluation is carried out after the media is ready to be used and has been evaluated independently by the researcher.

Table 1 <Media Validation Score>

Score Interval	Category
$X > 147$	Very high
$119 < X \leq 147$	High
$91 < X \leq 119$	Moderate
$63 < X \leq 91$	Low
$X \leq 63$	Very low

Table 2 <Material Validation Score>

Score Interval	Category
$X > 79.8$	Very high
$64.6 < X \leq 79.8$	High
$49.4 < X \leq 64.6$	Moderate
$34.2 < X \leq 49.4$	Low
$X \leq 34.2$	Very low

Result of validation review. The media validation in the first stage is the expert validator assessing the game content. Game content assessment consists of nine aspects consisting of 35 statements. So that the maximum score that can be obtained is 175 and the minimum score is 35. The results of the validator's assessment of the media can be seen in Table 3.

Table 3 <Media Validation by Validators>

Assessment Aspect	Max. Score	Validator 1	Validator 2	Average
Content Quality	10	10	9	9.5
Learning Objectives	15	14	12	13
Procedures and Feedback	20	20	15	17.5
Affective	15	13	13	13
Interface Design	60	57	47	52
Interactivity	30	29	22	25.5
Accessibility	10	9	10	9.5
Usability	10	9	9	9
Standard Conformance	5	4	4	4
	Total			**153**

From the table above, the assessment of media validity by experts shows that the BM adventure game media is in a very high category. Material validation on the media has also been carried out. Validation is intended to see how appropriate the content, presentation, and visual communication are for the material presented in the game. The results of material validation on the media can be seen in Table 4.

Table 4 <Material Validation by Validators>

Assessment Aspect	Max. Score	Validator 1	Validator 2	Average
Content Eligibility	45	36	42	39
Presentation Eligibility	20	15	19	17
Visual Communication	30	25	28	26.5
	Total			**82.5**

Based on the results of material validation on the media, an average value of 82.5 was obtained. The validated BM adventure game media was then revised by the researcher. Media revisions are made based on comments and inputs given by the validator. After the media is revised, a limited trial will be conducted.

Limited Trial. The limited trial in this study was conducted to review whether the BM adventure game media was feasible to be applied in the implementation stage or not. Through a limited trial, researchers received comments and suggestions regarding the BM adventure game media. This trial phase is carried out to minimize deficiencies and errors in the BM adventure game when used in the implementation phase.

The subjects involved in the limited trial were 4 students and 1 mathematics lecturer. BM adventure game media is given to test subjects to be used on smartphones or PCs. The test subjects were asked to run the game at least up to level 3.

Revision. Based on the results of the evaluation in the previous stage, data regarding the quality of the media, responses to the media, criticism, and suggestions from experts, lecturers and students were obtained. Several kinds of data are then analyzed to find out the weaknesses and advantages of the developed edutainment game media. Next, the researcher conducts an analysis to determine which parts need to be improved, replaced, or continued.

To get decent GEM, it is necessary to revise the GEM based on the comments and suggestions that have been received. The revision of this GEM was carried out twice and gradually. The first revision was made after getting comments and input from the validator. The second revision was carried out after the limited trial was

completed. 1) Implementation. After GEM is used in the learning process, the next activity is to carry out tests and fill out questionnaires. The test was conducted to determine the mathematical problem-solving ability after using the GEM. While filling out the questionnaire to find out the practicality of the GEM. The assessment of mathematical problem-solving ability test results refers to the indicators of mathematical problem-solving abilities. These indicators assess how students can solve mathematical problems which are represented in four stages. First, students can identify the problem. Second, develop a settlement strategy or modelling. Third, do the completion and evaluate the results. Assessment of media practicality is based on five aspects. First review how the use of media. Second, related to the ease of access, operation, and the level of difficulty of the challenges in the GEM. Third, reviewing whether the media presents activities that support interactivity. Fourth, the function of media in increasing user interest. Finally, review the level of creativity that exists in the GEM; 2) Evaluation. The evaluation stage in this study was aimed at determining the feasibility of the BM adventure game as a medium for learning mathematics in logic material. To find out whether the BM adventure game is feasible or not as a learning medium, an evaluation of three aspects is carried out. The first evaluation was carried out and see the feasibility of the BM adventure game from the aspect of its validity. Furthermore, evaluation is carried out after the media is used by students and lecturers/teachers to see the level of effectiveness and practicality.

Product Validity. The validity of the BM adventure game media was reviewed based on the results of expert validation of media content and material presented in the media. Media validation assesses nine aspects including; "(1) the quality of media content; (2) learning objectives; (3) procedures and feedback; (4) affective; (5) interface design; (6) interactivity; (7) accessibility; (8) reusability; and (9) standard conformity". In contrast to material validation on media, material validation also has its assessment aspect. Material validation on the media reviews the feasibility of content, presentation feasibility, and visual communication.

The results of media validation by the validator are 141 and 165 respectively. Based on this assessment, obtained an average of 153. The media validation assessment concludes that the BM adventure game has a very high media validity.

In addition to validating media, the validator also validates the material contained in the BM adventure game. Material validation in the media reviews three aspects including; (1) the appropriateness of the content of the material in the media; (2) the feasibility of presenting the material on the media; and (3) visual communication related to how the material is given.

The results of the validation of the material on the media by experts obtained scores of 76 and 89. The conclusion of the material validation assessment in the BM adventure game has a very high material validity.

Based on the validity assessment, it can be concluded that the BM adventure game meets the validity aspect with a very high category. The validity of the BM adventure game has met the validity of the media assessment based on the LORI indicator which assesses the efficiency of media use (Leacock & Nesbit, 2007). The overall media validity assessment indicators have consistent internal quality and meet media development theories (Plomp & Nieveen, 2010). Therefore, the BM adventure game media can be said to be feasible as a medium for learning mathematics, especially on logic material from the aspect of its validity.

Product Practicality. After analyzing the validity of the media, an analysis of the results of the media practicality questionnaire was also carried out. The practicality questionnaire reviewed the practicality of the BM adventure game as a learning medium. The summary of the results of the BM adventure game practicality questionnaire can be seen in Table 5.

Table 5 <Level of the Practicality of the Media>

Score	Category	Percentage
$X > 92{,}4$	Excellent	0.00%
$74{,}8 < X \leq 92{,}4$	Good	81.91%
$57{,}2 < X \leq 74{,}8$	Fair	18.09%
$39{,}6 < X \leq 57{,}2$	Poor	0.00%
$X \leq 39{,}6$	Very Poor	0.00%

The results of filling out the practicality questionnaire of students obtained that 81.91% considered the BM adventure game as a practical learning medium on good category and 18.09% considered it quite fair practical. Lecturers can organize practical learning using technology-based games (van Rosmalen et al., 2013). The results of the observations also show that the BM adventure game is practically used in the learning process. It is shown that the lecturers do not do many learning activities such as lectures or explaining the material. Activities are more dominated by student activities trying to complete the BM adventure game.

The practicality assessment obtained is also influenced by the easy accessibility of the media. The level of ease of accessibility is an aspect that can determine the level of practicality of the media (Bourgonjon et al., 2009). The BM adventure game has a small size of 22 MB so it does not meet the capacity of Android smartphones and PCs. In addition, the easy installation process also makes the BM adventure game a practical learning medium.

Overall the practicality of the media depends on how the management and development of the media have been done (Fuqoha, 2015). The BM adventure game is designed with attention to the challenges and missions that must be completed. Pay attention to the balance between the challenge of the game and the level of difficulty of the material presented. Management and development that pays attention to these aspects also make the BM adventure game practical as a medium for learning mathematics, especially in studying logic material.

Product Effectiveness

The evaluation of the BM adventure game media after it is declared valid and practical, an assessment of its effectiveness will be carried out. The assessment of the effectiveness of the media was reviewed based on the results of the mathematical problem-solving ability test. The mathematical problem-solving ability test reviews four indicators, including: the ability to understand the problems presented; formulating a settlement strategy that will be carried out; perform the solution with mathematical operations or analysis; and re-examine the correctness of the results or answers that have been obtained.

The mathematical problem-solving ability test focuses on the material that has been taught through the BM adventure game, namely the material of mathematical logic. The results of the mathematical problem-solving ability test will be used to assess the feasibility of the media from the aspect of its effectiveness. BM adventure games are said to be effective if they meet the following two criteria; more than 80% of students have mathematical problem-solving skills at least in the high category; and the average student's mathematical problem-solving ability is at least in the high category.

The summary of the results of the mathematical problem-solving ability test can be seen in Table 6.

Table 6 <Mathematical Problem-Solving Ability Test Results**>**

Score	Category	Percentage
$X > 80$	Very High	12.77%
$60 < X \leq 80$	High	68.09%
$40 < X \leq 60$	Moderate	17.02%
$20 < X \leq 40$	Low	2.13%
$X \leq 20$	Very Low	0.00%

The results of the mathematical problem-solving ability test have met the first effectiveness criteria. Analysis of the test results showed that 68.09% of students' mathematical problem-solving ability scores were in the high category and 12.77% were in the very high category. Therefore, 80.85% of students have mathematical problem-solving skills in the minimally high category. In conclusion, the results of the mathematical problem-solving ability test meet the first criteria, namely more than 80% of students have mathematical problem-solving abilities at least in the high category.

Furthermore, the results of the mathematical problem-solving ability test also meet the second effectiveness criteria. In summary, the average mathematical problem-solving ability test of students can be seen in Figure 4. The results of the analysis show that the average mathematical problem-solving ability test is 68.34. If the average is converted to the effectiveness category, then the high category is obtained.

Based on the analysis on Figure 6 the mathematical problem-solving ability test, it can be concluded that the BM adventure game meets the effectiveness criteria. The analysis that has been done also shows that the effectiveness criteria obtained are in a good category. Therefore, the BM adventure game can be said to be feasible as a medium for learning mathematics from the aspect of its effectiveness.

The results of this study illustrate that a well-organized game can be an effective medium for learning mathematics. Through a series of activities that have been passed, the BM adventure game media can become an effective medium. The results of the student's mathematical problem-solving ability test after using the BM adventure game were in the high category. Research results (Alkan & Ada, 2023) also show the same thing that through game-based learning media, students' mathematical abilities can improve much better.

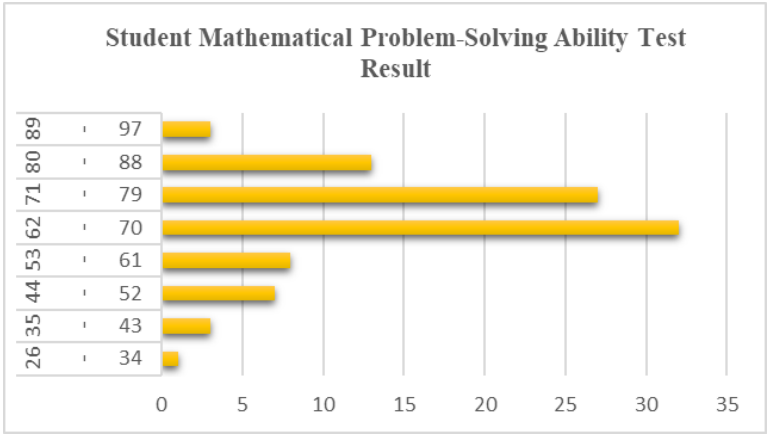

Figure 6 <Diagram of Mathematical Problem Solving Ability Test Results>

If analyzed more deeply, the effectiveness of game-based media starts from its function which can attract students' interest. The results of Ardani's research (2018) also show that game-based media can significantly increase interest in learning. This is because learning media in the form of games that present challenges and contain competition have great opportunities in increasing student interest in learning (Cagiltay et al., 2015). Furthermore, high interest in students will certainly encourage students to make more efforts. Self-interest can encourage a person to acquire knowledge and skills using various methods (Demise, 2006). In the end, high interest can influence understanding and the ability to solve mathematical problems (Sirait, 2016).

If we look at the characteristics of the BM adventure game, there are stimulus activities that can help students improve their mathematical problem-solving abilities. This stimulus can stimulate changes in students' thinking patterns, from a total lack of understanding of the direction of completion to a better understanding (Wiyatno & Hidayat, 2023). This is in line with behaviorist learning theory, which states that stimulus-based learning can improve problem-solving abilities (Oktariska et al., 2018). Through this stimulus, students' initial knowledge is raised, so that students' efforts can be directed to the next stage (Yuliana et al., 2017).

Choosing the best strategy and using it is an important skill for students to be able to solve problems effectively. The challenges in the BM adventure game encourage students to build concepts independently. The process of building concepts independently with the help of the instructions provided helps students recognize the structure of the concept (Hwang et al., 2015). After understanding the concept structure well, students can apply it to similar or more complex problems (Poerwanti et al., 2022). The guided strategies contained in the BM adventure game aim to help students explore the best answers and implement them.

The BM adventure game has presented several challenges and competitions that can attract students' interest in learning. In addition to the content of the BM adventure game that attracts students' interest, the delivery of material designed in the game also influences students' mathematical problem-solving abilities. The material presented in the game is not described directly, but students need to analyze and complete challenges to find out the concepts and principles being studied. The process of discovering the concepts and principles being studied, emphasizes deep understanding. This is because the learning process that involves direct activities makes information more secure in entering long-term memory (Bailey, 2017).

Conclusions

The development research that has been carried out has produced a product, namely an Android-based edutainment game to improve the mathematical problem-solving ability of prospective mathematics teachers, which is named the BM adventure game. The BM adventure game development process is carried out using the ADDIE development stage. After the BM adventure game was developed, an assessment was carried out to review the feasibility of the media. The results of the assessment show that the BM adventure game meets the following criteria: 1) The results of the expert's assessment show that the BM adventure game meets the aspects of validity both in terms of media content and the material presented. There is a category of validity obtained from the very high expert judgment. 2) The results of practicality assessments by both lecturers and students show that the BM adventure game meets the practicality criteria, 81.91% of students considered that the media met the good category. 3) The results of the mathematical problem-solving ability test show that the BM adventure game meets the effectiveness criteria, namely: a) 80.85% of students have mathematical problem-solving skills at least in the high category; b) the average mathematical problem-solving ability of students is

68.34 which is included in the high category. 4) GEM with activities that provide stimulus, guided strategies, and feedback can promote mathematical problem-solving abilities.

In conclusion, this study is founded on two perspectives: issues and demands, as well as the importance of mathematical problem-solving abilities and technological utility in the future. In general, lecturers now play a larger role in controlling learning activities (Hidayat, 2002; Satrio & Utami, 2019). This is demonstrated by the fact that the lecturer's ability to transmit information will have a significant impact on learning performance. Aside from that, learning is more concerned with the quantity of material that can be taught to students in the time provided than the quality of student achievement. Students do not have the opportunity to learn independently and take full responsibility for their knowledge. The results of a preliminary study by researchers revealed that of 115 students (pre-service mathematics teachers), 72.18% possessed mathematical problem-solving abilities in the sufficient category.

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