

Development of Mathematics Adventure Educational Game on SPLDV Material to Improve Students' Mathematical Connection Ability

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Abstrak

Rendahnya kemampuan koneksi matematis siswa dalam pembelajaran, khususnya materi SPLDV menjadi pendorong dilakukannya penelitian ini. Alat bantu seperti media pembelajaran permainan edukatif sangat diperlukan untuk meningkatkan hubungan matematis. Penelitian ini bertujuan untuk menyediakan media pembelajaran yang valid, praktis, dan efektif untuk meningkatkan kemampuan koneksi matematis siswa dalam bentuk game edukasi Mathematics Adventure pada materi SPLDV. Jenis penelitian ini adalah penelitian pengembangan (Research and Development) model ADDIE yang terdiri dari lima tahapan yaitu, analysis, design, development, implementation, dan evaluation. Uji coba produk dilakukan pada siswa kelas VIII SMP Negeri 3 Batanghari. Instrumen pengumpulan data menggunakan validasi ahli, angket respon siswa, dan tes. Hasil penelitian menunjukkan game edukasi Mathematics Adventure sangat valid berdasarkan penilaian para ahli, respon siswa memenuhi standar sangat praktis dan hasil belajar efektif untuk meningkatkan kemampuan koneksi matematis siswa.

Kata Kunci: Game Edukasi; Kemampuan Koneksi Matematis; SPLDV.

Abstract

The low level of students' mathematical connections in learning, particularly in SPLDV material, is the impetus for this research. Educational game learning media tools are necessary to enhance mathematical relationships. This study aims to provide legitimate, practicable, and effective learning media in the form of Mathematics Adventure educational game on SPLDV material to enhance students' mathematical connection abilities. This research follows the ADDIE model of Research and Development, consisting of five stages: analysis, design, development, implementation, and evaluation. The product was tested on the eighth-grade students of SMP Negeri 3 Batanghari. Data collection instruments included expert validation, student response questionnaires, and tests. The results indicated that the educational game Mathematics Adventure was highly valid based on expert assessment, student responses met practical standards, and learning outcomes were effective in improving students' mathematical connection abilities.

Keywords: Educational Game; Mathematical Connection Capability; SPLDV.

I. INTRODUCTION

Mathematical abilities are very important to be owned and mastered by students who study mathematics (Purnomo, 2021). The National Council of Teachers of Mathematics (NCTM) states that there are five mathematical skills that students need to master in order to succeed in math class: problem solving, reasoning and proof, connection (connection), communication (communication), and representation (representation) (NCTM, 2000). When learning mathematics, certain concepts are utilized to explain others or as prerequisites for other concepts (I. Lestari, 2018). In order to study mathematics, one must possess the capacity to connect ideas, ideas inside ideas, and mathematics to real-world applications. Students need to possess this skill in order to answer a mathematical issue. The mathematical connecting ability is what many name this skill (Naryaningsih, 2018).

Mathematical connections will broaden students' understanding of the subject and help them develop a favorable attitude toward math in general (Lasmawati, 2011). Students will be able to comprehend mathematical ideas that are interrelated and build concepts off of one another to construct everything that is interconnected as a result. This will help students realize and apply the relationships between mathematical concepts in an indirect manner. If students' insights are open, students will have the skills to solve a problem in a reasonable, in-depth manner, be responsible, and be based on intelligent thinking. (Lestari, 2014). According to NCTM (Isnaeni et al., 2019), shows that

connections in mathematics are broken down into three groups of connections that will be indicators of students' abilities to make connections in mathematics, namely: 1) connections between math topics, 2) connections with other sciences, and 3) connections with students' real world/connection with daily life. Because they can see the connections between topics in mathematics, with contexts outside of mathematics, and with experiences from everyday life, students who are able to make mathematical connections are able to relate mathematical ideas, which leads to a deeper and more lasting understanding of mathematics (Sugiman, 2008).

It was clear from the researchers' direct interviews with class VIII SMP Negeri 3 Batanghari instructors that the students' mathematical connection abilities were still rather lacking. The results of the students' daily tests on the content covered by the Two-Variable Linear Equation System, with 35% of class VIII students previously scoring below the KKM, supported this claim. By posing three questions with mathematical connections, the researcher tested 10 grade IX students who had studied the SPLDV material. Therefore, it can be concluded that the three indicators of the students at SMP N 3 Batanghari's mathematical connection ability are still low based on the results of teacher interviews, which were supported by student learning outcomes, namely daily tests, and based on the results of the researcher's pretest. In line with the research results of Riosanddy Nazaretha, et al (Narazetha et al., 2019) that class VIII students at one of the Public Middle

Schools in Cimahi City, In order to solve issues involving the Material of Two Variable Linear Equations System (SPLDV), the students' mathematical connection skill is still at an extremely low level. This is evident from the results of categorizing students' mathematical connection abilities, which show that many students still struggle to apply previously studied concepts to the concepts in the Two Variable Linear Equation System (SPLDV) material. This is especially true for students who have a very low ability to solve problems relating to other materials (Muharomi & Afriansyah, 2022). So, from this exposure, students' mathematical connection abilities must be improved. To improve students' mathematical connection skills, it is necessary to have a tool to make it easier for students to develop their connection skills.

The intended tool is in the form of a math educational game that can influence students' interest and enthusiasm in the learning process (Handayani et al., 2019). Currently, many games are played on personal computers and mobile phones (Abdi & Karneli, 2020). In the last few decades, ownership of mobile devices has increased (Pambudi, 2018). Thus, combining learning mathematics with game applications in one smartphone device becomes an interesting learning media innovation to implement. In addition, the math teacher at SMPN 3 Batanghari also has not used math learning media, especially math educational games. Games used in learning are often referred to as educational games (Naryaningsih, 2018). Educational games are games

designed and created to stimulate the mind, including increasing the ability to concentrate and solve problems (Wati & Istiqomah, 2019). The selection of game types is important in the development of educational game media. According to App Annie, one type of game that is in great demand to be played today is the adventure type (Ardyanto & Pamungkas, 2017). Games with the adventure genre allow players to feel they are really on an adventure to complete a mission. In addition, games of this type emphasize exploration, and puzzle-solving and sometimes involve conceptual problems (Nurrahma, 2018). According to Putri Dwi Naryaningsih's research (Naryaningsih, 2018), students' mathematical connection skills are 'Effective' after utilizing the multiplayer game she created, and their test results on mathematical connection exercises fall into the 'High' and 'Medium' categories.

Based on the description above, the researcher is interested in developing the Mathematics Adventure educational game on SPLDV material to improve students' mathematical connection abilities that are valid, practical, and effective.

II. METHOD

This type of research is research and development (R&D) model ADDIE which consists of five stages, namely, analysis, design, development, implementation and evaluation (Rustandi, 2021). Respondents to the product trial conducted at Batanghari 3 Public Middle School included 10 students in class VIII.2 to provide suggestions for the media before being

tested on the trial target and 23 students in class VIII.3 who were the target of the media effectiveness trial. The data collection instrument in this study used expert validation instruments as media validity analysis, student response questionnaires as media practicality analysis, and tests as media effectiveness analysis. Data analysis techniques performed are as follows.

An expert validation sheet is a tool used to determine if the educational game Mathematics Adventure has been appropriately constructed or not. The instrument used to analyze the validity of the assessment questionnaire was media experts and material experts. The assessment questionnaire is in the form of a Likert scale with a vulnerability of 1-5. Recapitulation data from expert validation results are calculated using Microsoft Excel with the following formula (Nuryanah et al., 2021).

$$P = \frac{\text{the total score obtained}}{\text{max score}} \times 100\%$$

Information:

P = Percentage of average value

The eligibility criteria can be seen in the following Table 1 (Dina, 2021).

Table 1.
Expert validation criteria

Quality Score	Eligibility Criteria
$84\% \leq P \leq 100\%$	Very Valid
$68\% \leq P < 84\%$	Valid
$52\% \leq P < 68\%$	Valid Enough
$36\% \leq P < 52\%$	Less Valid
$20\% \leq P < 36\%$	Invalid

From table 1, the feasibility of the educational game being developed, researchers have a minimum target of

getting a percentage of 68% or on valid criteria.

Practicality analysis was carried out by processing the data obtained from the results of the student response questionnaire. The practicality criteria can be seen in the following Table 2 (Dina, 2021).

Table 2.
Criteria for the practicality of the mathematics adventure educational game

Average validator score	Category
$84\% \leq P \leq 100\%$	Very Practical
$68\% \leq P < 84\%$	Practical
$52\% \leq P < 68\%$	Pretty Practical
$36\% \leq P < 52\%$	Less Practical
$20\% \leq P < 36\%$	Very Less Practical

From Table 2, the practicality of the educational game being developed, researchers have a minimum target of getting a percentage of 68% or on practical criteria.

The results of the students' mathematical connection ability tests can be used to analyze the success of the Mathematics Adventure Educational Game. Test result data was examined to determine the percentage of student completion. The following formula is used to perform the analysis (Agustya, 2017).

$$p = \frac{p_1}{p_2} \times 100\%$$

Information:

p = Percentage of student completeness

p_1 = Number of students who completed

p_2 = Total number of students

Furthermore, if students' ability to connect mathematical concepts improves as reflected in the results of the pretest and posttest for each indicator, the effectiveness of the Mathematics Adventure Educational Game can be

deemed successful. The Minimum Completeness Criteria (KKM) of 63 is used in this study as a benchmark for achieving completeness. Students who score 63 or higher are considered to have completed their studies. Pretest and posttest scores are the primary data used to determine growth in mathematical connection abilities. The data is analyzed using the N-Gain formula between the pretest and posttest to determine the test score outcomes. The optimal score is attained when the N-Gain effectiveness requirements are met. The Hake formula in Meltzer can be used to compute, as shown below. This study, known as N-Gain (Nainggolan & Erlinawaty, 2020), uses the N-Gain formula, which can be used to determine the increase in competency that occurs before and after learning.

$$N - Gain(g) = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}}$$

Information :

S_{post} = Posttest Scores

S_{pre} = Pretest Scores

S_{maks} = Ideal maximum score

The categorization by Hake, as presented in the following Table 3, is then used to explain the findings of the N-Gain calculation.

Table 3.
N-Gain Score Criteria

Score	Category
$g \leq 0,7$	High
$0,3 \leq g \leq 0,7$	Moderate
$g \leq 0,3$	Low

(Hake, 1999)

The N-Gain value, expressed as a percent (%), can be used to determine the N-Gain Score category. The following table

4 shows the different N-Gain acquisition categories.

Table 4.
N-Gain Effectiveness Category

Percentage (%)	Tafsiran
< 40	Not Effective
40 – 55	Less Effective
56 – 75	Effective Enough
> 76	Effective

(Hake, 1999)

III. RESULT AND DISCUSSION

The instructional game Mathematics Adventure, based on SPLDV material (System of Two Variable Linear Equations), is the product of this project. Ispring Suite 10, Website 2 APK Builder, and Microsoft Power Point were used to construct this instructional game. The ADDIE development paradigm has been used as a guide for the study and development of this instructional game.

A. Analysis Phase

Specifically, the researcher looked at issue analysis, curriculum analysis, material analysis, and study of student characteristics at this level. First, conversations with math instructors at SMP Negeri 3 Batanghari were used to analyze the problems. From the interview activities, information was obtained that the characteristics of students at SMP Negeri 3 Batanghari had low mathematical abilities in SPLDV material 35%, medium 40%, and high abilities of 25% based on data on daily tests scores. Every teacher has difficulties in getting all students in one class to understand math material, such as their basic math skills are still low, students have too much material to learn, and mathematical formulas are considered abstract for some students (Amallia &

Unaenah, 2018). In addition, the Batanghari 3 Public Middle School teacher explained that during face-to-face mathematics learning the teacher only used simple media and only used material in the textbook. Facilities such as mobile phones may be used during learning, there are no projectors, and the computer facilities that are there are only two or three computers. So, the appropriate alternative is to use a mobile phone as a learning medium.

Furthermore, curriculum analysis was carried out at SMP Negeri 3 Batanghari through interviews. The results obtained are the curriculum used in Batanghari 3 Public Middle School, namely the revised 2013 curriculum so that the learning media for the Mathematics Adventure educational game is developed based on this curriculum.

Third, material analysis was carried out by observing and reviewing several books, especially the 2017 revision of the 2017 class VIII semester math package published by the Ministry of Education and Culture. This is because the book is the main learning resource used in SMP Negeri 3 Batanghari.

B. Design Stage

At the design stage, a design for the Mathematics Adventure educational game was created using PowerPoint. The first step begins with designing or compiling a Mathematics Adventure storyboard. The storyboards that are made include the storyboard of the opening and the contents of each scene in the educational game. After making storyboards they collect game components such as pictures, sound, writing, and music. Image components

created include backgrounds, animated images, and button images. All components are obtained by downloading on the internet, the type of image chosen is a file of type png. The second step is the structure of the educational game structure that has been made and is included in the PowerPoint application which includes the initial appearance, main menu, materials, evaluation, learning videos, instructions for using the application, and indicators. Then the last step is making the initial product shape or design of the mathematics adventure educational game product.

C. Development or Production stage

In the development stage, several things are done after the product prototype has been made before, namely making educational games and validating product feasibility. The first stage of development after the design phase is completed is arranging the order of presentation of the game by utilizing the hyperlink facility where each menu page can be linked completely and quickly. In the second stage, if all menus have been made using PowerPoint slides arranged with hyperlinks, then disable the mouse and all buttons on the PowerPoint slide. This is done so that each menu in the game does not move slides when clicked anywhere, and each menu in the game can only be accessed with the buttons provided. The third stage, making an evaluation using iSpring with the type of question essay. After all the steps above are completed, all menus in the mathematics adventure educational game are published using iSpring. Then create an educational game application using the help of the 2 apk builder website.

Additionally, validation of the product's viability includes both quantitative data as the primary data and qualitative data in the form of feedback and ideas from the validators. The process of validating educational game products is carried out by expert validators and solicits theoretical and practical suggestions and input. Expert validators consist of media experts and material experts. Two experts, a mathematics lecturer and an IT lecturer, validated the media experts. The two media experts' validation results had an average score of 85%, which falls between $84\% \leq P \leq 100\%$ according to the expert validation criteria in table 1, putting the instructive math adventure game in the "very valid" category as in the following Figure 1.

Hasil Validasi Ahli Media

No	Aspek Penilaian	Kriteria	Nilai	
			Validator 1	Validator 2
1.	Kemudahan	A1	5	5
2.		A2	4	5
3.		A3	4	4
4.	Tulisan	A4	4	4
5.		A5	4	4
6.		A6	4	4
7.		A7	5	4
8.		A8	4	4
9.	Suara	A9	4	5
10.		A10	4	4
11.	Keterpaduan	A11	5	4
12.		A12	5	3
13.		A13	5	4
14.		A14	4	4
Jumlah			61	58
Total			119	
Skor Maks			140	
Rata-rata			85%	
Kriteria Valid			Sangat Valid	

Figure 1. Validator results from media experts

Based on Figure 1 above, this educational game is suitable for conducting product trials on students at SMP N 3 Batanghari. The revisions based on criticism and suggestions from media expert validators are as follows.

Table 5.

Revision from Media Experts

Before Revision	After Revision
	
Previously, if they answered the wrong question, students had to repeat the game from the beginning. It had been changed so that students did not repeat the game but were allowed to answer again.	
	
Previously the font in the question was too small then it was enlarged and replaced.	
	
Previously the application logo was too busy and not attractive, but it was made simple to make it more attractive.	
	
Previously, the level menu instructions in the game were incomplete, so they had to be supplemented with an additional padlock image to explain that the level was still locked.	





While the results of the material expert validation obtained an average value of 88% which lies in the range $84\% \leq P \leq 100\%$ according to the table 1, which means that the material in the mathematics adventure educational game "very valid" criteria in the following Figure 2.

Hasil Validasi Ahli Materi				
No	Aspek Penilaian	Kriteria	Nilai	
			Validator 1	Validator 2
1.	Materi	B1	4	5
2.		B2	4	5
3.		B3	4	5
4.		B4	4	4
5.	Isi	B5	5	5
6.		B6	4	5
7.		B7	3	4
8.		B8	5	5
9.		B9	4	5
10.	Bahasa	B10	4	4
11.		B11	4	5
12.		B12	5	4
13.		B13	5	4
Jumlah			55	60
Total			115	
Skor Maks			130	
Rata-rata			88%	
Kriteria Valid			Sangat Valid	

Figure 2. Validator results from media experts

Based on Figure 2 above, this educational game is suitable for conducting product trials on students at SMP N 3 Batanghari. The revisions based on criticism and suggestions from media expert validators are as follows.

Table 6. Revisions from Material Experts

Sebelum Revisi	Setelah Revisi
	
Given an indicator menu that contains indicators and basic competencies.	
	
Obstacles about level 1 are changed to direct students to understand the material.	

It can be determined that the mathematics adventure educational game is in the highly valid category with an average overall validation of the two experts of 87% after getting the average validation of media experts and material experts.

D. Implementation or Delivery Stage

Products that have been revised by the validator are then tested to find out student responses to the practicality of educational games and student test results. The following is the documentation and student test results using the media.



Figure 3. Documentation and student test results using mathematics adventure media

The results of the small group trial which consisted of 10 students in class VIII.2 of SMP Negeri 3 Batanghari and the large group which was the target of the trial consisted of 23 students in class VIII.3 of SMP Negeri 3 Batanghari, produced a positive response to the mathematics adventure educational game. The overall average result obtained is 97.94% and is included in the "very practical" criteria. Then the result of the pretest mastery percentage of mathematical connection ability before using the mathematics adventure educational game was 8.70% with an average score of 38.5 while the posttest mastery of mathematical connection ability after using the mathematics adventure educational game was 95.7% with an average score 91.1. Therefore, it can be said that the educational game's mathematical journey helps pupils get better at making mathematical connections. The following graphic illustrates how students'

mathematical connection skills improved between the pretest and posttest.

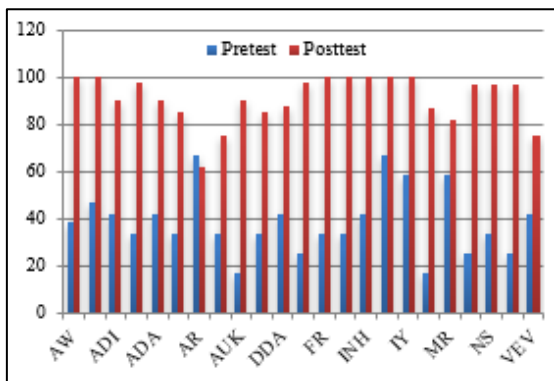


Figure 4. Diagram of the results of the Improved Pretest and Posttest of Students' Mathematical Connection Ability

The findings of the aforementioned pretest and posttest for mathematical connection ability demonstrate a substantial gain in scores for 22 students and a decrease in scores for 1 student on the final test of connection ability. Additionally, the following table provides statistical information on N-Gain scores associated with students in large groups, specifically class VIII.3, and their ability to make mathematical connections.

Table 7.
N-Gain Score Statistical Data Mathematical Connection Ability

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	23	-.14	1.00	.8334	.25425
Ngain_Persen	23	-14.11	100.00	83.3355	25.42490
Valid N (listwise)	23				

According to the statistical data table above, the big group trial class achieved an average mathematical connection ability score of 0.8334, placing the class's total N-Gain score in the top category. Based on the interpretation category of N-Gain effectiveness, the average N-Gain percent achieved in the big group is 83.3%, which falls into the effective category. Therefore,

the mathematical adventure educational game based on SPLDV content has been shown to successfully enhance students' mathematical connection skills.

E. Evaluation Stage

The final stage of the ADDIE development model is the evaluation stage. Because this study only used small-group and large-group tests, the evaluation in question is an evaluation of the implementation stage. Researchers only carry out the evaluation stage for students who are the target of trials only as learning media. During the trial, the researcher found no errors or criticism from the respondents, so no final revision was made to the Mathematics Adventure educational game.

The final product of this development study is a mathematics adventure educational game that can be used using Android by downloading the application via the [link https://www.mediafire.com/download/xb9y3b8cqt915y/](https://www.mediafire.com/download/xb9y3b8cqt915y/). Based on the expert validation procedure, which included media specialists and material experts, this product has satisfied the extremely valid standards. This is consistent with research by Putri Dwi Naryaningsih (Naryaningsih, 2018), who claims that students' mathematical connection ability is low in Indonesia and that one reason for this is that students dislike mathematics or have a bad attitude toward it. So that the use of educational games has the potential to have a positive impact on developing students' mathematical connection abilities in learning (Permatasari et al., 2020).

The educational games developed are designed to be attractive and able to motivate students in learning which contain games, materials, learning videos, and evaluations to achieve the expected competencies. This was demonstrated by product testing done by researchers, who had excellent results and found that students were enthused about utilizing the mathematics adventure instructional game to study SPLDV subject. Student enthusiasm was seen during small group trials to large group trials when students read problems and answered questions about mathematical connection ability well so educational games were included in the very practical criteria. This is in line with research conducted by Hanum Nurrahma (Nurrahma, 2018) who said that students agreed and responded positively to learning using this game because educational games were developed to understand mathematical concepts, innovative mathematics learning media were more interesting, and provided opportunities for students to practice mathematical connection skills in solving each problem independently through practice questions and evaluation in the educational game. In addition, from the results of student tests, the mathematics adventure educational game was also effective in improving mathematical connection skills. This is consistent with studies by Shinta Permatasari, et al. (Permatasari et al., 2020), who claim that educational games have the ability to improve students' understanding of mathematical connections.

IV. CONCLUSION

This research produced a product in the form of the Mathematics Adventure educational game on SPLDV material to improve students' mathematical connection skills which are valid, practical, and effective. In order to maximize student learning outcomes, researchers advise instructors should be able to offer innovations in the use of learning media to promote student interest in learning. The research is limited by the fact that the game's development only allows for big group trials by choosing one class VIII.3, thus further field trials (alignment) must be developed in order to improve the accuracy of the data.

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