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Development of an Evaluation Tool for Mathematical Communication Based on RPG Educational Games

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Abstract: This research aims to develop an innovative and interesting evaluation tool in assessing and improving students' mathematical communication through Role-Playing Game (RPG) based educational games. RPG educational games were chosen because they can provide an in-depth context for students' learning experiences, while facilitating interaction and collaboration. This evaluation tool includes a variety of mathematical tasks that students must complete through interaction in a carefully designed virtual world. The research method used is the research and development method, with the research model being the ADDIE model which consists of five steps, namely: (1) analysis, (2) design, (3) development (development), (4) implementation, and (5) evaluation. This research was tested for practicality on 15 respondents consisting of 8 students and 7 students, and validated by one supervisor. The results of this research were obtained as follows: (1) the practicality test assessment for the game operation indicator was 82.22% (very good), the game presentation indicator was 83.96% (very good), for the game benefit indicator it was 90.00 % (very good), and for the overall indicator obtained 85.83% (very good). In the validity test, the percentage obtained for the game presentation indicator was 93.75% (very valid), the percentage for the game benefit indicator was 84.88% (very valid) (2) he cognitive ability assessment obtained was 90.53% (very good) for the value student average, the student's achievement of completeness in each indicator has met very well, seen from the average of each question, the first question obtained a score of 98%, the second question was 86.3% and the third question was 87.3% of maximum score of 100% for each indicator. This research contributes to the mathematics education literature by combining aspects of technology, educational games, and mathematical communication

Keywords: Evaluation tool, Mathematical communication, RPG educational games

Introduction

Mathematics is a field of study that occupies an important role in the school curriculum. Republic of Indonesia Law Number 20 of 2003 concerning the National Education System article 37 expressly confirms that mathematics is one of the compulsory subjects for schools at the primary and secondary education levels. One of the objectives of learning mathematics according to the National Education Standards Agency (BSNP) is for students to be able to use mathematics as a way of reasoning (logical, analytical, systematic, critical, creative thinking and the ability to work together). In mathematics, students are not only limited to calculating, but students must have comprehension skills, mathematical communication skills, reasoning and problem solving (Sabandar, 2009). One of the mathematical skills that students must have is mathematical communication.

Mathematical communication skills are part of the basic skills that students must master to understand mathematical concepts or ideas conveyed by the teacher. According to Lestari and Yudhanegara (2015), mathematical communication skills are useful for understanding and receiving mathematical ideas from peers and teachers. In learning mathematics, mathematical communication skills are also useful in expressing their

ideas about mathematics and clarifying their understanding. According to Chasanah et al. (2020), mathematical communication also plays a role in understanding mathematical concepts and procedures, representing these concepts, and applying them in everyday life. In line with the statement (Yaniawati, 2019) that mathematical communication skills can also affect many things in mathematics learning and everyday life.

In the process of learning mathematics, communication skills to transform a problem into another form so that it is easier to understand both orally and in writing are very important. According to (Hirschfeld-Cotton, 2008), mathematical communication is an important key to understanding and exploring mathematical ideas. Good mathematical communication skills must be possessed by students, because mathematical communication skills are one of the basic abilities that must be developed in learning mathematics. According to NCTM (2000) mathematical communication skills are the ability to organize ideas or understanding clearly and logically to others both orally and in writing. So that mathematical communication skills can help internalize mathematical concepts better. According to Cai (1996), mathematical communication skills are communication between students and teachers in the process of learning, understanding, and conveying mathematical ideas, especially in expressing student thinking related to the problem solving process either in writing or orally. NCTM (2000) emphasizes that strong mathematical communication skills are important to help students become good problem solvers. Therefore, mathematical communication skills are very important for students to be able to solve mathematical problems by using good reasoning, illustrating mathematical ideas into mathematical models, then connecting the process to various mathematical concepts, into the context of everyday life, or into other contexts and disciplines. Mathematical communication is not only limited to concept mastery, but also the ability to convey mathematical ideas clearly and persuasively. Therefore, the development of evaluation tools that focus on aspects of mathematical communication skills is essential.

Evaluating mathematical communication skills is often challenging. Conventional evaluation methods that mainly focus on written answers do not fully reflect students' mathematical communication skills. A good evaluation tool should be able to measure various aspects or indicators of mathematical communication skills (Ramdani, 2012) Therefore, there is a need for dynamic and contextual evaluation tools that can provide a more comprehensive picture of students' mathematical communication skills. One of the dynamic evaluation tools is by utilizing information technology.

According to Restiyani et al. (2014) information and communication technology is a set of tools that can be used to collect, process, store, analyze, prove, and disseminate important information effectively and efficiently. To support the student-centered learning process in the digitalization era is to utilize information and communication technology. According to OECD (2018) Mastery of ICT is needed to equip students to have the ability to create new values through creative, innovative, collaborative, algorithmic, and open-minded thinking. The benefits of information and communication technology have been felt by all circles of society including teachers and students. One of the mathematics learning media that utilizes information and communication technology is mathematics educational games.

One of the evaluation tools that can be used to assist the learning process is educational *game* media, one of which is found in *role playing* games (RPG). According to Pramudtya et al. (2017) Educational games are games designed or made with learning elements to stimulate thinking including increasing learning motivation. While RPG games are a type of game that is played by playing a character who has a story or story in it. So, RPG educational games are defined as a form of game that has a story in it and is designed with elements of mathematics learning in it so that it is useful to support the teaching and learning process in a more enjoyable and more creative way. It is used to provide teaching or increase knowledge. Based on Frobel's experience as a teacher, he realized that play activities and toys that children enjoy as students can be used to attract attention and develop their knowledge (Tedjasaputra, 2001). The existence of *role playing games* (RPG) in assisting the learning process is based on the increasing use of *smartphones* which are generally widely used by students and teachers. Educational games have been proven to be an effective tool in increasing student engagement and understanding of mathematical concepts. The integration of game elements can make learning more fun and encourage students to actively engage. In this context, the use of educational games as the basis for evaluation tools promises to be an interesting approach to measuring students' mathematical communication skills.

This research aims to develop an evaluation tool that utilizes educational game principles to measure students' mathematical communication abilities. This tool is expected to create a dynamic and contextual evaluation environment, reflecting the actual situation where mathematical communication skills are needed. The research question is: How is the design of RPG game media based on students' mathematical communication skills? and How is the quality of RPG *game* media in terms of two aspects, namely validity and practicality?

Method

This research is a development research. The development research method is a research method used to produce certain products, and test the effectiveness of these products (Sugiyono, 2016). Researchers conducted research on the development of evaluation tools for mathematical communication skills based on RPG educational games in flat-sided space building material. In this study, the research flow used refers to the procedure proposed by Roiser and Molenda and Tegeh and Irna(2013), the ADDIE model consists of five steps, namely: (1)*analyze*, (2)*design*, (3)*development*, (4)*implementation*, and (5)*evaluation*. The following is the research flow of developing an evaluation tool for mathematical communication skills using RPG educational games:

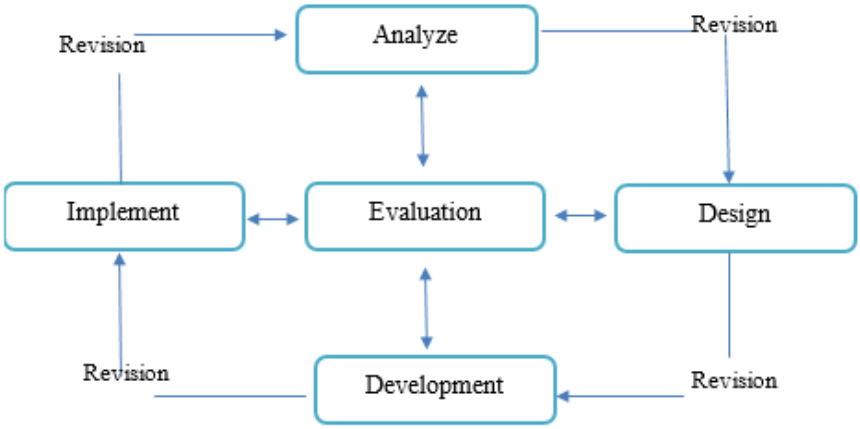

Figure 1. Addie development research flowchart (Branch, 2009).

The subjects of this study were VIII grade junior high school students, the students involved as research subjects consisted of 15 student respondents, and were tested for validation by one supervisor in a limited trial. The data collection techniques used are questionnaires and question instruments. According to Sugiyono (2016) Questionnaire is a data collection technique that is done by giving a set of questions or written statements to respondents to answer. Questionnaire is a data collection tool in research in the form of a series of questions submitted to respondents to get answers (Kurniawan: 2021). The preparation of questionnaire instruments is used to analyze the quality of games based on two aspects of validity and practicality in terms of respondents' responses regarding their RPG game tools. Meanwhile, the instrument functions as a tool to measure a person's knowledge in a particular subject (Fraenkel, Wallen, & Hyun: 2018). The test question in the study is a research instrument that contains a series of questions to test students' maematis communication skills on flat-sided space building material integrated with the RPG game. The data analysis technique used to determine the validity of RPG game media on flat-sided flat building material is by using a questionnaire. Research expert validators in RPG game development research are flat-sided flat building material experts, media experts, and small groups of junior high school students.

Results and Discussion

Analysis Stage

According to Pramuditya et al. (2018) that students' mathematical abilities are still undeveloped because learning is still teacher-centered. In addition, according to Pramudity et al. (2022) based on the results of interviews with students that the teaching materials used are still focused on textbooks. The textbooks used cannot be studied independently by students because they are not accompanied by illustrations that support the learning process.

Based on the results of a questionnaire given to 70 respondents from various types of work, 43 respondents stated that flat-sided building material was a difficult material. Of the 43 respondents who said it was difficult, there were 26 students, 14 students, 3 employees. The parts of flat-sided geometric figures that are considered difficult for students to understand are the calculations and answering various questions.

Teaching materials are really needed to support the delivery of material in class, based on the results of the questionnaire, it is stated that the teaching materials used by students in learning to build flat-sided spaces are varied, including using school modules/LKS, textbooks, e-books, the internet and teaching aids. Based on the results of the questionnaire, 40 out of 70 respondents were of the opinion that the teaching materials used could not be studied independently but had to be guided by teachers in face-to-face classes. But not only that, 48 out of 70 respondents stated that learning activities require fun evaluation tools as a supplement to teaching materials to make it easier to understand the material.

This was then complemented by 32 out of 70 respondents stating that they often use computers/laptops/smartphones to support mathematics learning and 64 out of 70 respondents stated that they agreed to the existence of teaching media made from educational games and 58 out of 70 thought that RPG game teaching media was very interesting and interactive. This resulted in 60 out of 70 respondents thinking that educational games were suitable to be applied to flat-sided building materials. And for understanding the material, 24 out of 70 respondents stated that it was easier to understand through pictures/illustrations/animations, presentation of the material, example questions and examples of application in everyday life.

Design Stage

At this stage, several activities are carried out, including the following:
a. Create a story scenario taken from the Wuragil folklore which contains an overview of the game storyline being developed.
b. Create and design basic components that will be used in Dewatis games. These components include:

1) *Map*. The map creation is adjusted to the story scenario chosen in the learning media being developed. The map is made as interesting and similar as possible to the story of the Wuragil so that students really feel the storyline in the game. The Dewatis game is made into 4 maps with each map designed not to be too complicated by taking into account the students' time in exploring the map so that it will not result in students getting bored.

Figure 2. Map 1

Figure 3. Map 2

Figure 4. Map 3

Figure 5. Map 4

2) Character generator, character generator is a term that indicates the creation of a character in the game. Having the right characters will certainly make students more interested in using the game. The main characters for exploring the map are made into 7 characters. However, in the game only 4 characters can be displayed.

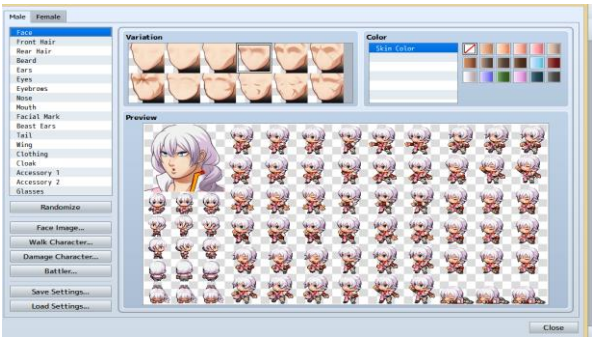

Figure 6. Character generator

3) Animation. The animation chosen in this game is adapted to the flat-sided spatial material. The animation inserted into the game is in the form of a learning video.

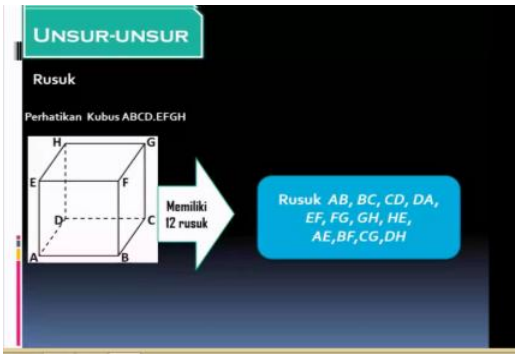

Figure 7. Animation video

4) Sounds and music. In this media there are several sounds and accompanying music that are adapted to the situation and place in the game.even though it's in the same place. RPG Maker MV software has provided it all in the database.

5) Text. The conversation text is adapted to the wuragil story scenario. Then conversation texts are created for each character in the game. Texts for various things supporting the storyline in the game are also created, such as texts for prologues, epilogues, and so on.

Figure 8. Text conversation

c. Create evaluation questions for flat-sided geometric material that has indicators of students' mathematical communication skills.

Table 1. Lattice of mathematical communication questions

Mathematical communication ability indicators	Aspects analyzed	Question indicator	Number of question
Express and illustrate mathematical ideas into mathematical models	1. Identify data from the question sentence 2. Create a mathematical model 3. Solving the math model 4. Accuracy in calculating using mathematical symbols	1. Connecting everyday language with mathematical language by using symbols.	1
Express and illustrate mathematical ideas into mathematical models	1. Create a mathematical model of the picture problem 2. Able to solve the math model in writing 3. Accuracy in calculating using mathematical symbols	2. Reflect and clarify thinking about mathematical ideas.	2
Express and illustrate mathematical ideas into mathematical models	1. Accuracy in making mathematical models from what is heard 2. Able to interpret mathematical ideas into the form of mathematical models 3.Able to solve the model model in writing 4.Accuracy in calculating using mathematical symbols	3. Using the skills of reading, listening, evaluating, interpreting mathematical ideas.	3

d. Preparation of research instruments to be used, namely a media validation questionnaire for media experts and a media practicality questionnaire for students.

Development Stage

Development of an RPG Game Evaluation Tool

At the development stage, the action process of making evaluation tools with the help of RPG Maker MV software is carried out. This stage is a continuation of the design stage where researchers begin to translate the previously designed design into a real product. In addition, researchers carried out the process of integrating mathematical communication questions into the RPG game.

Figure 9. Question number 1 on rpg games

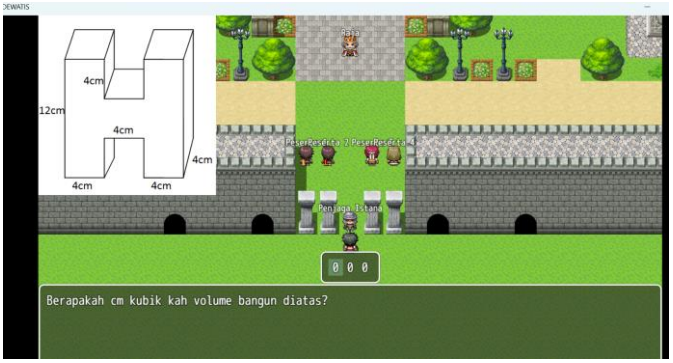

Figure 10. Question number 2 on rpg games

Figure 11. Question number 3 on rpg games

Media Validation

Based on the Table 2, the assessment by the validator is divided into two indicators, namely the presentation of the game and the benefits of the game. The game presentation indicator consists of games that have clear objectives (1a) given a score of 3, the presentation of material about flat-sided space in the game is easy to understand (1b) given a score of 4, the presentation of questions in the game (1c) given a score of 4, the game application has no bugs in the application (1d) given a score of 4. The game benefit indicator consists of the game giving curiosity about the folklore of the wuragil (2a) given a score of 3, the game raises the interaction

between the user and the game presented (2b) given a score of 4. The percentage obtained on the game presentation indicator is 93, 75% (very valid), the percentage on the game benefit indicator is 87, 5% (very valid).

Table 2. Media expert validation results

Respondent	Number of question game presentation tool				Benefits of game tools		Total score
	1a	1b	1c	1d	2a	2b	
S1	3	4	4	4	3	4	22
total score	15				7		22
percentage	93,75 %				87,5 %		91,67%

Media Practicality

This section aims to test the product through game design practicality assessment. This RPG game assessment is carried out by junior high school students who have studied flat-sided space building material.

a. Assessment of mathematical RPG si wuragil game products by the supervisor as a reviewer, and filling out an assessment instrument that contains a description of several indicators / aspects of learning media quality criteria.

b. Testing the product produced to 15 student respondents and asking for assessments and responses.

c. Analyzing the results of the RPG game assessment.

Table 3. Rpg game practicality questionnaire by users

Respondent	Game operation			Game presentation as an evaluation tool								Benefits of games as an evaluation tool			Total Score
	1a	1b	1c	2a	2b	2c	2d	2e	2f	2g	2h	3a	3b	3c	
S1	3	3	3	4	3	4	4	3	4	2	2	3	4	3	45
S2	2	3	2	3	3	3	3	3	3	2	3	3	3	1	37
S3	4	3	4	3	3	3	4	4	3	2	3	4	4	3	47
S4	4	3	4	4	3	4	4	4	4	3	4	4	3	3	51
S5	4	3	4	3	3	3	4	4	3	2	3	4	4	3	47
S6	4	3	4	4	3	4	4	3	4	4	4	4	4	4	53
S7	4	3	4	4	4	4	3	4	4	3	4	4	4	4	53
S8	4	1	4	4	3	1	4	3	3	4	3	4	4	4	46
S9	4	4	4	3	4	2	4	3	3	3	3	4	4	3	48
S10	4	1	4	4	4	1	4	3	4	3	3	4	4	2	45
S11	3	1	4	4	4	1	4	4	4	3	4	4	4	4	48
S12	4	2	4	4	4	3	4	4	4	3	4	4	4	4	52
S13	3	4	3	4	3	4	3	3	3	4	4	3	3	4	48
S14	3	3	4	4	3	3	4	3	3	3	4	4	3	4	48
S15	3	3	3	3	3	2	4	3	3	3	4	4	4	3	45
Total score	53	40	55	55	50	42	57	51	52	44	52	57	56	49	713
Total Score	148			403								162			
Percentage %	82,22			83,958											84,88

Based on the data table above, it is obtained that: for the game operation indicator obtained 82.22% or included in the very good category with the game can provide instructions during the game that facilitate the operation of the game and can be operated on PC and Android; for the game presentation indicator obtained 83.96% or included in the very good category with the game can be understood clearly and easily, both in terms of language, purpose, or flow that provides material and story information as well as the appropriate sound and image background in the game; For the indicator of the benefits of the game, 90.00% or included in the very good category with the game can foster curiosity, flexible to play, and no errors occur when played; and for the overall indicator obtained 84.88% or very good category with the game can fulfill all the provisions of the indicator in the very good category. Therefore, it can be concluded that the RPG game as a learning media on the material of flat-sided space building junior high school grade VIII is very good or very practical to use for students.

Implementation Stage

Results of Students' Cognitive Scores

Based on the Table 4, the presentation consists of three questions with 20 questions each. The presentation of the questions is adjusted to indicators of mathematical communication skills, the first question is based on the indicator of connecting everyday language with mathematical language using symbols, the second question is based on the indicator of reflecting and clarifying thoughts about mathematical ideas, the third question includes two indicators, namely using the skills of reading, listening, evaluating, interpreting mathematical ideas and the indicator of using mathematical ideas to make conjectures and make convincing arguments. From the 15 respondents, a total score of 1358 was obtained with an average of 90.53% based on the conversion of the percentage of learning completeness. The information obtained was A for the students' average score, the students' attainment of completeness in each indicator was very good, seen from the average percentage of each question, the first question was obtained at 98 The second question's % was 86.3% and the third question was 87.3% of the maximum score of 20. Students getting the maximum score indicates that students have fulfilled all aspects of each indicator. Students got a score of 18 on indicators 1, 2, 3, this is because students are not precise in including mathematical unit symbols, this indicates that students are not observant and do not check their answers again when they have finished working, students who get a score of 10 on question number 2 because students only write down the volume of the building without including identification of what is known, step find the volume of blocks and cubes. Meanwhile, students who got a score of 15 completed the steps correctly at the stage of finding the volume of blocks and cubes, but the students did not continue to find the results asked about in the question. The student who got a score of 12 on question number 3 answered correctly, but the accuracy of including mathematical symbols and the accuracy of calculating were still wrong

Table 4. Results of student and university student scores

Name	Score			Total Score
	Question 1 (Max 20)	Question 2 (Max 20)	Question 3 (Max 20)	
S1	20	18	15	88,33
S2	20	18	18	93,33
S3	20	18	20	96,67
S4	20	18	18	93,33
S5	20	20	20	100
S6	18	15	18	85
S7	18	18	18	90
S8	20	20	20	100
S9	20	15	15	83,33
S10	20	20	12	86,67
S11	20	18	20	96,67
S12	20	10	20	83,33
S13	20	18	18	93,33
S14	18	18	15	85
S15	20	15	15	83,33
Total	294	259	262	1358
percentage (%)	98	86,3	87,3	90,53

Based on the research results above, from 15 respondents the overall average was 90.56 with a scale value of A and very good information. It was concluded that students' mathematical communication skills using RPG were categorized as good.

Evaluation Stage

The evaluation tool based on mathematical educational game design has several advantages and disadvantages including:

Advantages

a. Learning media in the form of educational games makes students more interested in learning
b. Has interesting animation and storyline

c. Easy to operate because it doesn't have many buttons, making it easier to operate the game
d. The material and questions about flat-sided shapes in the game are easy to understand
e. There are no bugs
f. The language and flow of conversation are easy to understand
g. The sound background and presentation of the game are appropriate

Disadvantages
a. The main players in the RPG application game character are a maximum of 4 players
b. The duration of the material video is too long

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

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