Kreano 12 (1) (2021) : 39-50
KREANO
Jurnal Matematika Kreatif-Inovatif
http://journal.unnes.ac.id/nju/index.php/kreano

Developing and Playing Geometric Puzzle Game to Enhance the Ability of Mathematical Creative Thinking

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History Article
Received: December, 2020 *Accepted: April, 2021* *Published: June, 2021*

Abstract

This study explores the development of the game media of the geometric puzzle to support junior high school students' mathematical creative thinking skills. The research design used in this R&D research uses a 4-D development model. The researchers present the prototype of an exciting game for stimulating students' creative thinking ability. Expert validation obtained an average value of 80.89%, the category is feasible (not revised). Students' limited trial score was 88.69% very interesting category and from the teacher 80% interesting category. The value of field trials to assess effectiveness through completeness obtained by students of 75.86% was categorized as complete classically. Therefore, the development of geometry puzzle game media with students' needs is feasible, interesting, and useful.

Abstrak

Penelitian ini mengeksplorasi pengembangan media permainan puzzle geometris untuk mendukung kemampuan berpikir kreatif matematis siswa SMP. Desain penelitian yang digunakan dalam penelitian R&D ini menggunakan model pengembangan 4-D. Para peneliti mempresentasikan prototipe permainan yang menarik untuk merangsang kemampuan berpikir kreatif siswa. Validasi ahli memperoleh nilai rata-rata 80,89% kategori layak (tidak direvisi). Nilai uji coba terbatas siswa 88,69% kategori sangat menarik dan dari guru 80% kategori menarik. Nilai uji coba lapangan untuk menilai keefektifan melalui ketuntasan yang diperoleh siswa sebesar 75,86% dikategorikan tuntas secara klasikal. Oleh karena itu, pengembangan media permainan puzzle geometri yang sesuai dengan kebutuhan siswa layak, menarik, dan bermanfaat.

Kata Kunci: Research and Development, Geometry Puzzle Games, Creative Thinking.

INTRODUCTION

Mathematics learning which was designed and implemented optimally could undoubtedly develop all the abilities that exist in students. One of them is the ability to think mathematically creatively. When students develop new ideas by combining previous ideas to solve mathematical problems, a process is the ability to think creatively (Siswono, 2006).

Students' creative thinking skills have not developed well and were still low. Thus, the lack of students 'mathematical creative thinking skills were directly proportional to their lack of reasoning abili-

p-ISSN: 2086-2334; e-ISSN: 2442-4218

ties. Students' mathematical creative thinking abilities were part of their reasoning abilities (Sasmita et al., 2015). On the previous research, it was found that one part of the concern is thinking in learning activities (Firdaus et al, 2016). Furthermore, another research revealed a vital ability to improve, and that was thinking creatively (Rudyanto, 2014). Based on the opinion, Permendiknas No. 19 states that learning mathematics by only providing convergent questions causes an active and creative learning process to be neglected (Widiastuti & Putri, 2018).

Students' ability in this research was a creative ability to develop a new idea in solving problems on topics "similarity" (Setya Putri et al, 2017). In line with the opinion, creativity in mathematics was more about the ability to think creatively (Noer, 2011). Someone who studies mathematics was mostly doing thinking activities. Providing opportunities for students to what they have in their thinking could improve students' creative thinking skills in school (Abdurrozak & Jayadinata, 2016). Researchers also conducted pre-research to find out the mathematical creative thinking skills of seventh-grade students in Pontianak. The pre-research was carried out by giving a mathematical creative thinking ability test with the indicator tested was flexibility, namely presented a rectangular image with its dimensions. Students were asked to make a flat shape with an area equal to the rectangular image. The results of the pre-research were presented in Figure 1.

Figure 1 shows the students who could solve the questions were 10% or three students. They could make different shapes, such as a parallelogram with the same area as the two-dimensional figure. Meanwhile, 26 students could not solve the questions, or 90%. They redraw the existing picture, meaning that they could not create a different two-dimensional figure with the same area as the two-dimensional figure. So from the results of these observations, it could be concluded that the creative thinking ability was still low. This was due to the teacher's lack of attention to students' mathematical creative thinking skills. Based on the results of teacher interviews in schools only focused on assessing student learning outcomes in general.

The pre-research results were corroborated by Sasmita et al (2015) who argue that creative thinking was less of a teacher's attention in learning mathematics, which was a factor in students' low ability to think creatively in mathematics. Learning mathematics in schools generally only trains convergent thinking processes, limited to verbal reasoning and logical thinking. Students will have difficulty solving problems creatively because students were used to convergent thinking. Besides, the teacher emphasis was always right, and the teaching was more on memorization due to the tight curriculum in schools. Learning like this could not improve students' mathematical creative thinking skills.

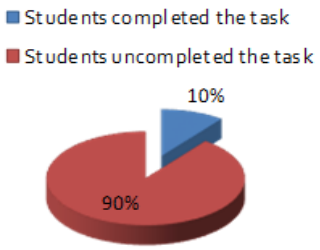

Figure 1. Pre-Research Results of Students' Mathematical Creative Thinking Ability on Indicator Fluency and Flexibility

Having encountered this problem, the media game was one alternative way of learning to improve students' mathematical creative thinking skills. A previous research have claims that game could be used to explain mathematics in the teaching-learning process (Lestari & Yudha-

negara, 2015). This game could help increase student motivation. When students seem to be not concentrating on the teacher's lesson, they were transferred to the game method for a particular time until they return to concentration. Furthermore, Lestari & Yudhanegara (2015), also explains how the teacher uses in presenting lessons by creating a fun, serious, but relaxed atmosphere without neglecting the lesson objectives to be achieved a game method. Games like this become an automation of understanding in students' cognitive systems to achieve learning objectives by following the game process.

According to the research, the steps for the game method were: a) The teacher determines the topic or game material to be used in learning; b) The teacher prepares the necessary tools and materials; c) The teacher arranges instructions or steps for implementing the game; d) The teacher explains the aims and objectives and the rules of the game; e) Students were divided into individuals or groups; f) Students do game activities led by the teacher; g) Students stop playing and report the results of the game; h) The teacher provides conclusions about the meaning and concepts referred to in these objectives.

In general, games will provide adequate benefits for students, as various media functions outside of school for students, as additional material for knowledge that they do not get at school. A tool used to help deliver material from the teacher during teaching and learning activities was called media (Suryana & Indrawati, 2018). Everything that could be used to transmit messages from sender to recipient to stimulate thoughts, feelings, attention, and interests and students' will so that the learning process will occur effectively was known as learning media (Nurhabibie, 2017). The learning media that was used, must be able to attract students' attention to teaching and learning activities and stimulate student learning activities more (Nugraheni, 2017). Media games that lead to education intending to improve mathematical skills were learning media that could activate students.

In supporting the teaching and learning process so that students understand and remember the teacher's material quickly and easily, the use of learning media was required (Nataliya, 2015). Thus, to stimulate children's brain development by providing learning in a way that is fun and not dull, help from parents is needed. Puzzle game provides Learning activities were active, not dull, increase understanding of the material, and fostering interest in learning could occur using game media (Oktaviana et al, 2017). Meanwhile, puzzle was a media that could be used to increase students' motivation and learning activities (Husna et al, 2017). She also stated that a kind of game in the form of pieces of an image that was how to play it by arranging them. An image was formed to train patience, making it easier for students to understand concepts, solve problems, cooperate with their friends, and develop students' motor and cognitive skills called Puzzles.

A researcher offers to use the puzzle as educational play for children's games because it was exciting and fun for schools (Chandra, 2019). It requires precision and accuracy in puzzle games, and children will be trained to focus their thoughts. They must concentrate when arranging puzzle pieces. This type of educational game trains the child's mindset in arranging pieces into one unit with a complete shape (Muloke et al (2017).

A research recommend that teaching aids to support the learning process was puzzles (Elan et al, 2017). Meanwhile, teaching aids to support the learning pro-

cess that uses puzzle pieces with geometric shapes were called geometric puzzle media. A previous research report that puzzle games have several advantages, namely: (1) puzzle games could attract students' interest in learning, (2) the images on the puzzle could overcome the limitations of space and time because not all objects could be brought into the classroom, (3) with the learning media students could see, observe and conduct experiments and could add insight (Husna et al, 2017).

Games in classroom learning could stimulate students' thinking skills. This is because, in the game, students will feel more happy and relaxed in learning. The puzzle game also requires students to concentrate more on arranging the puzzle pieces.

The game that fits the creative thinking skills in question was "Hatching the Egg". The "Hatching the Egg" puzzle game was a method of fun math learning games for students by arranging egg pieces to form birds that match the given picture in the form of a flat shape, then look for as many bird shapes as students could shape.

There was an explanation that "Hatching the Egg" was a form of the puzzle used in mathematics learning. As the name implies, the "Hatching the Egg" Puzzle game was closely related to eggs and birds. As we know that, a bird comes from the eggs. In learning that uses puzzle game media, each group tries to compile and then analyze this game. The "Hatching The Egg" Puzzle game's objective was to arrange the egg pieces so that they form a bird according to the picture given, then look for as many bird shapes as possible by the students.

The separated "Hatching the Egg" could be rearranged into one of the bird shapes shown in Figure 2.

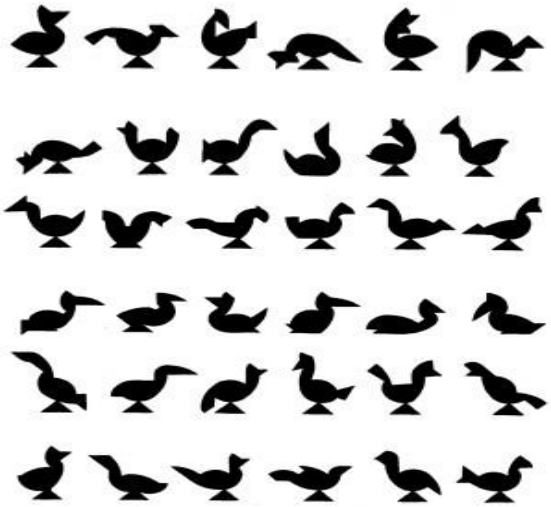

Figure 2. Some Examples of Poultry Forms Formed from the Puzzle "Hatching the Egg"

This "Hatching the Egg" was a game that will challenge students to precisely arrange ten egg pieces and form various bird shapes. By carrying out these activities, it supports students' understanding of geometry. Before they form a shape from these pieces, they must first imagine what that shape will look like. The students were allowed to investigate a real object or a picture or shape of the real object.

The development of the "Hatching the Egg" puzzle game method would ide new variations in mathematics learning and mathematical creative thinking skills. A previous research shows the same results as games that challenge students' creativity, and memory was more profound due to the emergence of motivation to always try to solve problems was a puzzle game (Harahap & Singgalinging, 2014). Furthermore, the games were exciting and fun and could improve cognitive abilities (Chamdika et al, 2016). Cognitive abilities such as classifying objects based on color, shape, or size could also train intelligence in solving problems referred to as a puzzle Game. In brief, this study extends the new variation and development of puzzle games to support students in learning mathematics.

METHOD

The researchers employed to research and development (R&D) and observed the classroom environment where the students engaged in creative thinking to explore research purposes. In this research, the media to be developed was the puzzle game media "Hatching The Egg". The development model used was a model developed by Thiagarajan et al (1974) known as the Four-D model. Rochmad (2012) argues that some development research in education refers to the Four-D model proposed by Thiagarajan, Semmel, and Semmel. RnD stands for research steps that could be interpreted as Define, Design, Develop, and Disseminate, adapted into a 4-P development model.

This study's subjects were seventh grader students of one secondary school in West Kalimantan. The students studied were taken using purposive sampling technique, namely through teachers' recommendations of related subjects. The test was used as the measurement technique. The test required the students to indicate their ability to think creatively by matching the picture corresponding to the tasks. Indirect communication techniques were media-assisted data collection techniques or using intermediaries. In this study, indirect communication techniques' objective was to see the media's validity and practicality. The media used in this collection technique was a questionnaire (questionnaire). Data collection tools were validation sheets consisting of media validation sheets and material validation sheets and questionnaires to determine the practicality of the media being developed and tests to determine the media's effectiveness. The data analysis technique used descriptive statistics in each measurement aspect, namely the validity aspect with the percentage formula, to achieve the indicators whose criteria were presented in table 1.

Table 1. Product Eligibility Level

Assessment	Value Scale	Percentage Rating Results %	Explanation
Very feasible	5	86% – 100%	No Revision
Feasible	4	66% – 85%	No Revision
Feasible enough	3	51% – 65%	Little Revision
Not feasible	2	36% – 50%	Revision
Impracticable	1	20% – 35%	Revision

(source: Riduwan (Yudhaskara & Tjahyaningtyas, 2016)

The feasibility of the development results in this study was that at least the assessment was quite feasible. Aspects of effectiveness using questionnaires and tests were calculated statistically descriptive, namely the percentage for the questionnaire and the average for the test assessment. The results of student and teacher response questionnaires using a Likert scale and a test of mathematical creative thinking skills in students were converted through classical completeness: a) Student and teacher response questionnaires. The data obtained from the student and teacher response process were analyzed in steps: 1) Calculating the percentage of the attractiveness of each aspect. 2) Calculate the average percentage of all students. 3) Changing the average score obtained into a qualitative value in accordance with the assessment criteria in Table 2.

Table 2. Student and Teacher Response

Average	Criteria
0% – 20%	Very Less Interesting
21% – 40%	Less Interesting
41% – 60%	Quite interesting
61% – 80%	interesting
81% – 100%	very interesting

(Lindawati, 2016)

With the Likert scale table, the researcher could see the percentage of student and teacher response attractiveness the media was developed. The results of

the students' mathematical creative thinking ability test would be presented in the form of descriptive statistics, and analyze the data with steps 1) giving a score to the posttest results; 2) Looking for classical completeness. Some of the obstacles encountered in the implementation of this research were conducting world research to fight against the Covid 19 outbreak which caused students to only operate online or use online learning. So that the tests carried out were not too optimal.

FINDINGS AND DISCUSSION

Findings

The research produces learning media types of geometry puzzle game on junior high school students' mathematical creative thinking ability. The following were the stages of implementing the 4-D model research and development activities limited to the Development stage.

Define

This stage was carried out to identify needs based on an analysis of the problems found. This stage aims to define and define the conditions for learning (Thiagarajan et al., 1974). Information will be collected at this stage, which will be used to develop the "hatching the egg" geometric puzzle game media as a learning medium. The stages carried out were a) Front-end Analysis. This stage was the first step taken by researchers to determine the problems experienced by students and teachers when the teaching and learning process was carried out.

Researchers found problems experienced by students when pre-research was carried out and interviews with the subject teachers concerned after pre-research was carried out. From the pre-research activities, it was found that the problem was that students could not solve problems related to creative mathematical thinking. Meanwhile, based on interviews with teachers of related subjects, the media had never been used in mathematics learning, and there was a shortage of teaching materials at the school.

Next, we have done Learner Analysis. At this stage, information about students was obtained through interviews from the teacher concerned, and pre-follow-up research after the first stage of pre-research was carried out. The observations that have been carried out were that students have difficulty working on questions in the form of stories that require students' creative thinking namely fluency and flexibility. The problem starts with seventh-graders because the materials will be related to materials at higher grade levels.

Furthermore, an analysis was carried out regarding the completion techniques that students usually use in answering questions. Based on the analysis results, information was obtained as a consideration in designing the geometry of the puzzle according to student needs. Task Analysis researchers determine competency standards and basic competencies under the syllabus. The basic competencies taken as the basis for geometric puzzles' preparation were compiling geometric shapes based on a combination of several other geometric shapes and solving area and perimeter problems from combined geometric shapes.

After learner analysis, we also have done the Concept Analysis. The researcher determines what material will be reduced to be developed in the geometry puzzle game in concept analysis. At this stage, the researcher also determines the appropriate related learning sources. By looking at Specifying Instructional, the researcher determines the learning objectives according to students' basic compe-

tencies and needs. Then, compile geometric shapes based on several other geometric shapes, solve problems related to the area and circumference of the combined geometric shapes, and the objectives of student needs, in the form of learning media that could help students learn. This step was also the basis for compiling tests and designing media containing geometry material that students will use during the learning process.

Design

The design stage was carried out to design the learning media that will be developed. The steps involved at this stage were the Constructing Criterion-Referenced Test (Compilation of Benchmark Tests). In this step, the researcher determines the mathematical creative thinking ability test, which consists of five questions used in the test instrument test. A test was a tool or procedure used to determine or measure something in an atmosphere with predetermined ways and rules (Arikunto, 2015). The test was built by adopting core competencies, basic competencies, and competency achievement Indicators in the syllabus. A test grid was used to assess based on the item scoring guidelines. After that, the trial was conducted at different schools to determine the effectiveness of the media being developed. A good question meets the eligibility criteria for item validity, distinguishing power, difficulty index, and reliability (Budiyono, 2011).

Media Selection. Media selection was made for the presentation of the learning content. The geometry puzzle game will arouse students' interest in studying mathematics, especially in geometric shapes. Format Selection. At this stage, format selection was made to determine the design that will be used in the product development. Initial Design. The following was the initial design of the geometry puzzle game

Figure 3. The Design

Develop

This stage aims to produce a revised product based on expert input and field trial data. The steps involved at this stage were a) Expert Appraisal (Expert Validation), Expert validation was needed to determine the validity of the product being developed. Validation was the first step in product development after the product's initial design was carried out. This step aims to determine the feasibility of the product and fix some product deficiencies based on expert input before the product trial stage was carried out in the field. In this study, the validation carried out was media validation. Three mathematics lecturers carried out media validation. The three experts provide an assessment based on an assessment sheet prepared according to the National Professional Certification Board (BSNP) assessment guide.

There were three assessment indicators regarding media validation, including media size, media design, and media content design. The assessment sheet was filled in by giving a check (√) on each assessment item. The measurement scale on the questionnaire uses a Likert scale, which was labeled Very Good (SB), Good (B), Fairly Good (CB), Poor (K), and Very Poor (SK). Apart from providing an assessment, the experts also provided comments and suggestions in the comments and suggestions column provided

to provide input and what things needed to be improved. Validation by a media expert was shown in Figure 4.

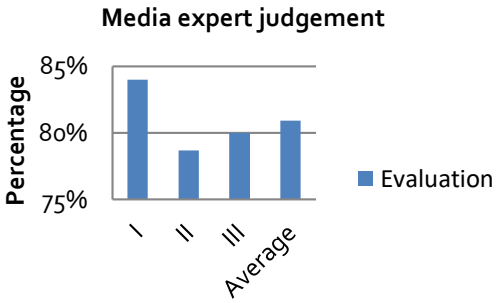

Figure 4. Media Validation Assessment

Based on three media experts' evaluation, an average rating of 80.89% was obtained with a decent category, and no need to revise. The media was suitable for use as learning media. Thus, the feasibility level of the geometry puzzle game media was feasible without revision.

Development Testing

There were two steps in this Development Trial stage, including a limited trial and a field trial. A limited Trial happened when the geometry puzzle has been validated and revised. The next step was to conduct a limited trial. 6 students conducted a limited trial. These students were selected based on the subject teacher concerned based on high, medium, low ability. Students and teachers were given an assessment questionnaire that has previously been validated by the same experts during media validation. Student and teacher response questionnaires were given to determine the effectiveness of the geometry puzzle game media.

The results of students' interest through a response questionnaire were shown in Figure 5.

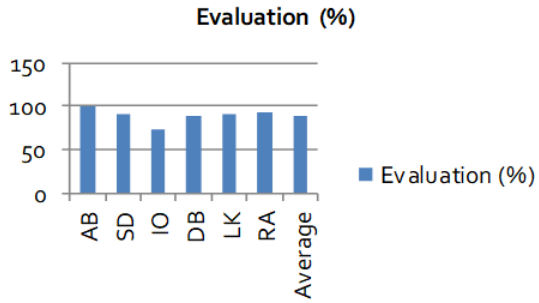

Figure 5. Assessment of Students' Interest

Meanwhile, for the questionnaire assessment, the teacher's response got an interesting category. Thus it could be concluded that the level of interest in the geometry puzzle game was 84.48% with a very interesting category. By obtaining the results of the student and teacher response questionnaires with a very interesting average rating, the research was continued to the field trial stage. Field trials were carried out on 29 students. Field trials were conducted to see the effectiveness of the geometry puzzle game previously tested on a limited basis. After learning on the geometry material assisted by the geometry puzzle game media, students were given post-test questions that have previously been tested in a school that has the same accreditation level as the target school and was declared fit for use. The post-test questions consist of five questions of essay type.

The post-test results were used to determine the level of effectiveness of the geometry game based on the Minimum Mastery Criteria (KKM) Mathematics, namely 75. The tests' results on students' mathematical creative thinking abilities used descriptive statistics to analyze the data. According to Satiadarma (Kurniasari, 2015) the characteristics of creative thinking according to Guilford were closely related to the five characteristics that characterize the ability to think, namely: (a) Fluency in thinking, (b) Flexibility. The results of the creative thinking test were presented in Figure 6.

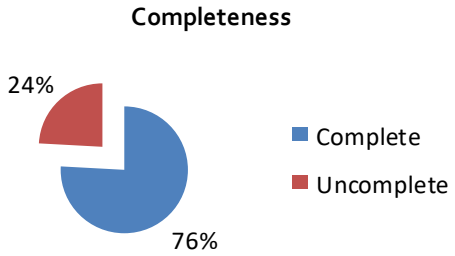

Figure 6. Student learning completeness

Figure 6 shows that the research subject class was complete learning because students complete it individually. The conclusion was based on the student and teacher questionnaire responses and classical completeness that the geometry puzzle was effectively used as a medium for learning mathematics in the classroom.

Discussion

The media development process for geometry puzzle game media uses the 4-D development model developed by Thiagajaran. This development model consists of 4 stages of development: Define, Design, Develop, and Disseminate. However, in this research, the stage carried out was only up to the Develop stage. This refers to the initial aim of this research to develop a viable and influential media in the third step of this development model, namely, develop.

Five steps must be taken at the defining stage, namely, Front-end Analysis, Learner Analysis, Task Analysis, Concept Analysis, and Specifying Instructional (Formulation of Learning Objectives). The defining stage begins with making observations during pre-research and interviews with the subject teachers concerned after the pre-research was carried out. From both results, it was found that students still had difficulty finding the area and perimeter of the combined shape.

After finding the problem with the teacher's help, the researcher determined the subjects for limited trials and field trials. Limited trial students were six students who have high, medium, and low abilities. Meanwhile, the field trial was conducted by 29 students. After determining the subject of limited trials and field trials, the next step was to determine the material under KI, KD, and Competency Achievement Indicators (GPA).

The next stage was the design stage. This stage aims to design the instruments and media that will be used. This stage was divided into two steps: the Constructing Criterion-Referenced Test, namely the preparation of tests of mathematical creative thinking skills that were tested in schools with the same level of ability. The second step was Media Selection; the researcher selects a geometric puzzle game. The third step at this stage is Format Selection. In this step, the researcher adjusts the material and media that has been selected. The final step in the design stage was Initial Design; this step was the design of the media before validation was carried out to conduct field trials.

The last stage carried out in this research was the development stage. The purpose of this stage was to produce the final product after validation and field trials. Based on the validation results that media experts have carried out, the product's average feasibility was 80.89% in the feasible category and does not need to be revised. The media was suitable for use as learning media. After validation, the researcher made revisions obtained from input from media experts.

Furthermore, the researchers tested the product twice, namely limited trials and field trials. The limited trial involved six students. Students were asked to assess development products through

student response questionnaires. The limited trial obtained that the average student response questionnaire to see product interest was 88.96% with very attractive criteria. An assessment was also carried out based on the teacher's response questionnaire to the product being developed. The assessment obtained was 80% with attractive criteria. From the results of the student and teacher assessment questionnaires that have been carried out, the average assessment to see product interest was 84.48% with the category **very interesting**.

Field trials were carried out to see the effectiveness of the geometry puzzle game being developed. The effectiveness of the media could be seen from the results of the post-test involving 29 students. From the post-test that has been carried out, classical completeness was obtained of 75.86%. So, the product gives a classical complete learning effect to students. This shows that puzzle geometry could train students to think new and unique things due to being creative in students' thinking (Yusuf in Kurniasari, 2015). This was also in line with research conducted by Suryana & Indrawati (2018) which produces traditional game-based learning media which have valid criteria for validation and average student learning outcomes. Likewise with the research conducted by Husna et al (2017) the puzzle media developed were suitable for use as a learning medium. Based on research results and supported by research that was in line, it could be concluded that the geometry puzzle game was useful in the learning process of mathematics in the classroom.

CLOSING

Conclusion

Based on the results of the development, research, and discussion of the puzzle game on the mathematical creative thinking ability of junior high school students, it could be concluded that the development of the puzzle game on the mathematical creative thinking ability in the classroom reaches the feasibility level with the proper category and does not need to be revised. The development of the puzzle game on thinking creatively mathematically in the classroom reaches an effectiveness level with a very interesting category. It gives students a classical complete learning effect.

Suggestion

The suggestions from this research were to become a viewpoint for readers and further researchers, namely 1) the games developed in this study could be continued by other researchers to the dissemination stage or distribution in other classes, by other teachers, and on a broader scale; 2) If other researchers continue this research to the dissemination stage and could continue this research not only within the scope of Pontianak city, but also to other areas; 3) The developed puzzle game still needs to be refined with further trials at the disseminate stage, in order to be useful and produce higher quality products.

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