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DEVELOPMENT OF MATHEMATICAL COMIC LEARNING MEDIA (KOMAT) BASED ON STUDENT'S MATHEMATICAL CONNECTION ABILITIES

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Abstract

The aims of this study were 1) to develop mathematical comics based on mathematical connection skills, 2) to find out student's responses to mathematical comics based on mathematical connection abilities. This research uses research and development procedures (Research and Development) or R&D. The model used in this study is the 4-D development model which consist of four stages of development, namely the define stage, the design stage, the develop stage, and the disseminate stage. The product trial subjects in this study were 29 students of grade VIII junior high school. The result of the study showed that the developed Mathematical Comics (KOMAT) met the criteria for being used as learning media. This can be seen based on the validation result of material experts of 3,35 with very suitable criteria for use, and media expert validation of 2,95 with appropriate criteria for use. On the result of product trials on students, based on the result of the questionnaire responses of students to the attractiveness of math comic learning media (KOMAT) it was obtained an average of 3,19 with attractive criteria. So it can be concluded that the mathematics comic learning media (KOMAT) based on students' mathematical connection abilities is feasible and interesting to use in school learning.

Keywords: *Mathematical Connection Ability, Comics, Development Learning Media*

INTRODUCTION

Mathematics comes from the Latin word mathematica, which is taken from the Greek word mathematice which means study. In education, mathematics is a strong basic science, because all branches of science involve mathematics. Mathematics is a general (universal) science that plays an important role in various scientific disciplines and develops human thinking power, as well as being the basis for the development of modern technology. Apart from that, mathematics is also a subject that can train students to think critically, logically, systematically and creatively.

Mathematics is a subject that is closely related to human life. Therefore, students must learn mathematics from the elementary school level to tertiary institutions (Mashuri, 2019). There are several math skills that must be possessed by students which have been mentioned in the National Council of Teacher Mathematics (NCTM), namely communication, reasoning, solving problems, associating ideas, and forming a positive attitude towards mathematics.

One of these skills is the ability to associate or connect mathematical ideas which is called a mathematical connection (Amin et al., 2019).

Mathematical connection ability is the ability of students to find relationships in a representation of concepts and procedures, understanding between mathematical topics, as well as students' ability to apply mathematical concepts in everyday life. According to NCTM, the indicators of students' mathematical connection abilities are divided into three aspects, namely 1) connection aspects between mathematical topics, 2) connection aspects with other sciences, 3) connection aspects with everyday life (Isnaeni et al., 2019). Based on this description it can be seen that the ability of mathematical connections is very important in the process of understanding mathematical concepts in students. But in fact, the research conducted shows that students' mathematical connection abilities are still low. This is because students have difficulty understanding the questions because students are still confused and have not been able to interpret the sentences presented (Sitaresmi et al., 2016). The average connection ability of students is still low with a percentage of 60% of 30 students having difficulty understanding questions that contain mathematical connection indicators given (Hayati et al., 2018).

Mathematical connections are very important to be developed in the process of learning mathematics. Learning that uses teaching materials based on mathematical connection abilities can create students' creativity in associating problems in questions and connecting in everyday life (Azizah et al., 2022).There is an effect of using comic media to improve students' mathematical connection abilities (Musyarofah et al., 2019). Other researchers also stated that there was an effect of using interactive multimedia learning media to improve mathematical connection abilities compared to conventional learning (Junedi & Sari, 2020). The results of this study prove that learning media is a suitable alternative to overcome the problems of students' mathematical connections.

Learning media is anything that can be used by the sender to the recipient to convey a message or information so that it can stimulate students' thoughts, concerns, feelings, and interests to learn. With learning media students can be motivated to learn, write, speak and imagine. Thus learning media can make the learning and teaching process between teachers and students more effective and efficient (Tafonao, 2018).

Along with the times, technology in the world is growing rapidly, learning mathematics is also required to keep up with technological developments that are developing in this global

era. Most students think that mathematics is boring, because mathematics material tends to be abstract. This is because teachers still use books or conventional printed teaching materials. The teacher only uses a book as the only teaching material (Yuniati & Sari, 2018). Teachers are required to be able to create fun learning that can attract students' interest so that students can be active, creative, and innovative in learning activities. One of the factors that can create a fun and interesting mathematics learning atmosphere is learning media (Tuzzahro et al., 2021).

In an effort to create interesting and fun learning, learning media are needed that relate to real experiences. Teachers must pay attention to the psychological level of the age of their students, what they like, their mindset, their level of understanding and so on. The goal is that teachers can make learning media according to the psychological level of students. That way it can attract the attention of students to be more motivated in carrying out learning. Based on these things, the need for learning media for mathematics is considered really needed by teachers and students (Syahwela, 2020).

There are many learning media that are generally used in the learning process, one of which is comic media. Comics are a learning medium whose presentation is accompanied by illustrations, models and pictures. Comic media can also be interpreted as learning media packaged in the form of illustrated stories with the aim of increasing understanding of concepts and building students' knowledge (Yonanda et al., 2019). Comics are equipped with interesting illustrations and everyday language that can help students understand the relationship between mathematics material and everyday life. In this case, the content of the comic can be created to provoke students' curiosity. With the help of the characters in the comic, students can be invited to solve a mathematical problem related to statistics material.

Comics are illustrated stories consisting of reading text and short dialogues. This will make it easier for the reader to understand a story. Comics as reading which contains cartoons that contain characters and act out a sequential story and are closely related to pictures and are designed to be entertainment for readers (Putra & Milenia, 2021). As a learning medium, comics function to convey information or messages in learning. In general, someone reads comics only as entertainment, but over time, teachers create comics as a learning medium that can attract students' interest in learning. Comics as a learning medium have several advantages, including: (1) in their presentation they contain strong visual and story elements, (2) they increase the reader's vocabulary, (3) they make it easier for students to grasp abstract

things, (4) has elements of a story sequence that contains a big message but is presented concisely and is easy to accept, (5) the visual expressions can make the reader emotionally involved which makes the reader want to continue reading

Learning media in the form of mathematical comics will be developed containing instructions that can make it easier for students to accept and understand Statistics material in everyday life so that it is closer to contextual values. One of the studies in the form of comics that have been carried out is research on the development of comics as a medium for learning mathematics for class VII SMP. The material contained in comic learning media is comparative material presented with the concept of everyday life in the form of adventure stories that allow students to learn independently. The developed media is classified as valid based on the validation results of material experts and media experts. Based on the results of trials on class VII students, comic learning media is classified as practical to use because it gets a very positive response from students and is classified as effective because all subjects have scored above KKM 75 (Witanta et al., 2019).

As a result of the researcher's interview with the mathematics subject teacher at MTs An-Nuur Guppi Mojopahit, Mrs. Lenny Marlina, S.Pd, information was obtained that the teaching materials used by the teacher were printed teaching materials in the form of textbooks and worksheets as teaching media applied in class. Students are also less able to understand the material independently without direct explanation from the teacher, and students' ability to relate mathematical concepts is relatively low and they still have difficulty relating the material to everyday life. During learning, there were also some students who did not pay attention to the teacher's explanation. One of the students also said that the thickness of the book made students lazy to open it and the appearance of the printed LKS book which was not accompanied by color made students uninterested. Mrs. Lenny also said that there is some material that is relatively easy, but in the learning process students find it difficult to understand the material, one of which is statistics material.

Based on the background described above, it shows that mathematics learning activities require learning media support in the form of comics based on mathematical connection capabilities in supporting learning, so that it is expected to attract students' interest. Therefore, researchers want to conduct research with the title "Development of Mathematical Comic Learning Media (KOMAT) Based on Students' Mathematical Connection Ability".

METHOD

This study uses research and development procedures (Research and Development) or R&D using a 4-D model. The subjects selected in this study were 27 class VIII B students of MTs An-Nuur Guppi Mojopahit. The material expert validators consist of two people, namely a mathematics lecturer and a mathematics teacher. The media expert validator consisted of two mathematics lecturers. This research and development used two kinds of data collection techniques, namely interviews and questionnaires consisting of material expert validation sheets, media expert validation sheets, and student response questionnaires. The validation sheet is used to determine the feasibility level of the product being developed. While the student response questionnaire is used to determine student responses to the attractiveness of the product being developed.

RESULT AND DISCUSSION

Defining Stage (Define)

Front-End Analysis

This analysis was carried out by interviewing teachers and students in order to obtain data related to the problems encountered in the learning process. Based on the results of interviews with the mathematics teacher at MTs An-Nuur Guppi Mojopahit, information was obtained that the teaching materials used by the teachers were printed teaching materials in the form of textbooks and LKS. Students are also less able to understand material independently without direct explanation from the teacher, and students' ability to relate mathematical concepts is low and they still have difficulty relating material in everyday life. The thickness of the book and the appearance of the LKS printed book, the presentation of which is not accompanied by color, makes students uninterested and lazy to open it.

The researcher also gave a questionnaire in the form of a google form to 31 class VIII students which contained several questions. Based on the results of the questionnaire, it was found that most students were interested in and chose comics as the learning media to use, because comics were presented in the form of pictures and stories. Students' curiosity about the contents of comics can foster students' interest in understanding learning material.

Concept Analysis

This analysis was carried out by identifying, detailing, and systematically compiling the main materials learned by students on the subject of statistics for class VIII MTs An-Nuur Guppi Mojopahit with reference to the 2013 curriculum. The material in this research and

development is statistical material. The material presented in this study is statistics with achievement indicators including mean (average), mode, median, range, and quartiles based on mathematical connection abilities.

Task Analysis

This analysis was carried out by way of interviews to identify basic competencies and learning indicators with the aim of identifying the main skills to be studied. The results of the analysis obtained an overview related to the expected tasks in learning that students must have in order to achieve a learning goal.

Specifying Instructional Objectives

This step is carried out by summarizing the results of concept analysis and task analysis to determine the behavior of the research object. This collection of objects is used as the basis for compiling tests and designing learning devices that have been included in learning materials.

Based on this analysis, the learning objectives will be achieved in the learning materials used. The purpose of using this math comic is to facilitate class VIII students of MTs An-Nuur Guppi Mojopahit to understand statistics material, attract students' interest in learning, and make it easier to understand the material. By utilizing this math comic, it is hoped that students can learn independently without direct explanation from the teacher.

Design Stage (Design)

Media Selection

Media is a tool that is used as a conduit for messages or information to achieve learning objectives. The learning media chosen is mathematical comic learning media based on mathematical connection abilities which aim to facilitate students in the learning process.

Format Selection

The choice of format in the development of this math comic is to design and design learning content. In math comic learning media, the format to be developed is based on mathematical connection abilities.

Initial Design

Based on the analysis that has been obtained, an initial design regarding the product in the form of math comic learning media was obtained before being tested.

Development Stage (Develop)

Before the product development of mathematics comic learning media (KOMAT) was tested on class VIII students of MTs An-Nuur Guppi Mojopahit, the authors conducted a due

diligence on material experts and media experts. As for the material expert test, the authors asked for help from one of the mathematics lecturers and a teacher to assess the feasibility of the learning media being developed. For media experts, the authors asked for help from two mathematics lecturers to assess the feasibility of the developed learning media. The results of the assessment obtained can be seen in the following table:

Expert Assessment

1) Validation of Questionnaire Sheets for Material Experts, Media Experts, and Student Response Questionnaires

The following are the results of the validation of the Material Expert Questionnaire, Media Expert, and Student Response Questionnaire:

Table 1. Assessment Sheet Validation Results

Number of Items	10
Max Score	40
x_i	3,7

Based on the table, the questionnaire assessment sheet to assess the feasibility of the Mathematical Comics (KOMAT) product developed by the author, received very suitable criteria.

2) Expert Validation

Table 2. Validation results from material experts and media experts

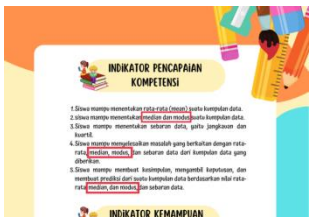
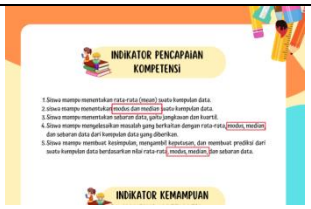
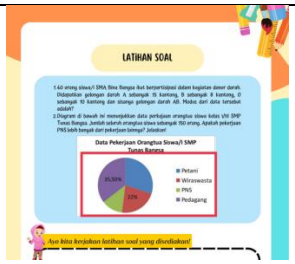
Validator Criteria	**Value Acquisition**		**Average**
	Validator I	**Validator II**	
Material Expert	3,57	3,14	3,35
Media Expert	2,7	3,2	2,95

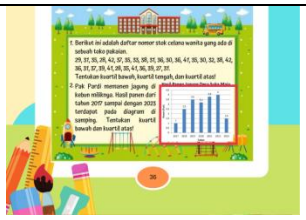
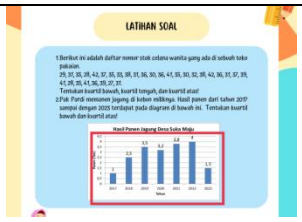
Based on the table, the mathematical comic product (KOMAT) developed by the author, in the validation of material experts, is included in the category of very feasible to use, in the validation of media experts, it is included in the category of appropriate use.

Product Revision

Based on the advice of material experts, there are several things that need to be corrected before being tested on students. The suggestions that need to be improved can be seen in the following table:

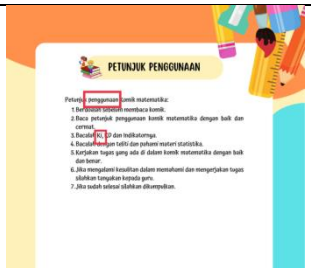
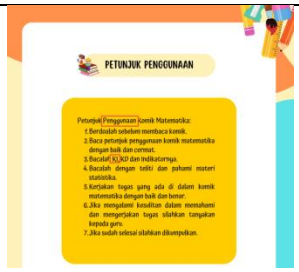
Table 3. Material Expert Suggestions and Results of Improvements

Improvement Suggestions	Repair Result
	
The median and mode are reversed, sorted according to the order of the material.	The median and mode sections have been reversed according to the order of the material.
	
Refine the mean formula, use notation and symbols.	The mean formula has been improved using notation and symbols.
	
Zoom in on the writing on the diagram.	The writing on the diagram has been enlarged.
	
The Average text should be fixed to a sequence, and enlarge the text size from the calculation.	The Average text has been fixed to a sequence, and the text size has been enlarged..
	
Add the median formula.	The median formula has been added.

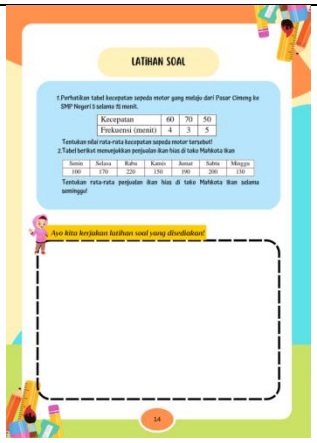
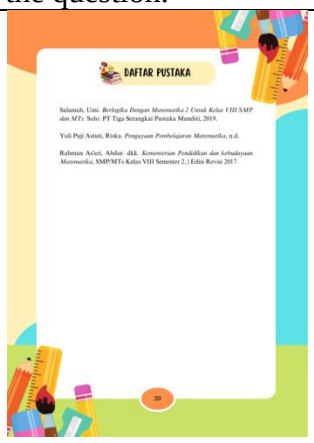
	
Enlarge the size of the chart and the writing on the chart.	The chart size has been enlarged.

Based on the advice of media experts, there are several things that need to be corrected before being tested on students. The suggestions that need to be improved can be seen in the following table:

Table 4. Media Expert Advice and Improvement Results

Improvement Suggestions	Repair Result
	
Add the word KOMAT to the title of the cover and fix the position, for Grade VIII SMP/MTs the cover is slightly lowered so that (Class VIII) is included in the circle.	The title has been added and the location has been corrected. For SMP/MTs class VIII the cover has been slightly lowered so that (Class VIII) is included in the circle.
	
Fix typo in writing and make shape.	The typo has been fixed and made into shape.

	
The frame on each sheet is minimized, the explanation of statistics is shortened and use your own description.	The frame on each sheet has been reduced, the explanation of statistics has been shortened and uses its own description.
	
Chat balloons don't need to use shadows.	Chat balloons have been fixed without using shadows.
	
Add conversations in each blank.	In each blank section a conversation has been added.

	
In the application of the median it is better if a comic is also made.	In applying the median, comics have also been made.
	
In each exercise a box is given to answer the question.	In each practice question, a box has been given to answer the question.
	
Add a glossary.	Glossary has been added.

Product Trials

At the product trial stage, researchers conducted trials on 31 class VIII B students at MTs An-Nuur Guppi Mojopahit. Product trials were carried out to see students' responses to

the attractiveness of mathematical comic learning media based on mathematical connection abilities in statistics material. At the time of the trial by filling out the questionnaire, there were several students who did not enter so that only 29 students gave response questionnaires to the developed KOMAT.

From the results of the student response questionnaire, it was obtained that the feasibility of mathematical comics was developed based on their level of attractiveness. The results of the student response questionnaire can be seen in the following table:

Table 4. Student Response Questionnaire Results

Data	Score
Number of Students	27
Total Average	3,19
Criteria	Interesting

Based on the results of trials on class VIII students at MTs An-Nuur Guppi Mojopahit, a total average result of 3.19 was obtained which was included in the criteria of interest.

Stage of Dissemination (Disseminate)

This stage is the last stage in the process of developing mathematical comic learning media. At this stage the dissemination of learning media products in the form of math comics was carried out to the schools studied, namely at MTs An-Nuur Guppi Mojopahit, but the researcher carried out the dissemination stage only to students who were the target of the trial and the teacher as reference material.

The Results of the material expert validation obtained a total average of 3,35 with the criteria "very suitable for use". Based on these results, it shows that this KOMAT learning media is suitable for use as a product trial test for MTs An-Nuur Guppi Mojopahit students. This KOMAT is based on students' mathematical connection abilities which is one of the choices of learning media used in honing students' abilities in connecting mathematical ideas, associating mathematical ideas with other sciences, and applying mathematical concepts in everyday life. and students can learn independently to understand the material presented. This is in line with research (Sitaresmi et al., 2016) which states that students' mathematical connection abilities are still low. This is because students have difficulty understanding the questions because students are still confused and have not been able to interpret the sentences presented. and supported by research conducted by (Hayati et al., 2018) which states that the average ability of students' mathematical connections is still low with a percentage of 60% of

30 students experiencing difficulties in understanding questions that contain indicators of a given mathematical connection. According to research conducted by (Musyarofah et al., 2019) states that there is an effect of using comic media to improve students' mathematical connection abilities. Students' understanding will be deeper if students can link between mathematical concepts and experiences in everyday life.

The results of the validation of media experts obtained a total average of 2,95 with the criteria "fit for use". Based on these results, it shows that this mathematical comic learning media is suitable for use as a product trial test for MTs An-Nuur Guppi Mojopahit students. This math comic is designed in an interesting way by containing storylines related to everyday life so that it can make it easier for students to understand the material in order to achieve the expected competencies. This math comic is also designed so that students can learn independently. This is in line with research (Azizah et al., 2022) which states that mathematical connections are very important to be developed in the process of learning mathematics. Learning that uses teaching materials based on mathematical connection abilities can create students' creativity in associating problems in problems and connecting in everyday life. Teachers are required to be able to create fun learning that can attract students' interest so that students can be active, creative, and innovative in learning activities. One of the factors that can create a fun and interesting mathematics learning atmosphere is learning media (Tuzzahro et al., 2021). One of the studies in the form of comics that have been carried out is research on the development of comics as a medium for learning mathematics for class VII junior high school. The material contained in comic learning media is comparative material which is presented with the concept of everyday life in the form of adventure stories that allow students to learn independently. The developed media is classified as valid based on the validation results of material experts and media experts. Based on the results of trials on class VII students, comic learning media is classified as practical to use because it gets a very positive response from students and is classified as effective because all subjects have scored above KKM 75 (Witanta et al., 2019). The results of this study prove that learning media is a suitable alternative to overcome the problems of students' mathematical connections.

Based on the results of the student response questionnaire submitted to 29 MTs An-Nuur Guppi Mojopahit students who had studied statistical material using math comic learning media on the attractiveness of math comics, a total average of 3,19 was obtained with

the criteria of "interesting". As for the results of data analysis on the mathematics comic learning media developed is interesting and can create a fun and not monotonous learning process. With the presentation of more innovative material such as pictures and stories as well as a colorful appearance, students can see the visual appearance of the material presented in math comic learning media. This is in line with research (Syahwela, 2020) which states that in an effort to create interesting and fun learning, learning media are needed that link to real experiences. Teachers must pay attention to the psychological level of the age of their students, what they like, their mindset, their level of understanding and so on. The goal is that teachers can make learning media according to the psychological level of students. That way it can attract the attention of students to be more motivated in carrying out learning. And backed by research (Witanta et al., 2019) Comic media can be used as an alternative for teachers in the learning process. This is shown in the acquisition of an average percentage of student responses of 92% with a very positive category, which means students like the use of comics as a learning medium in class.

CONCLUSION

Based on the validation results of the material experts, a total average of 3.35 was obtained with very suitable criteria for use, from the validation results of media experts, a total average of 2.95 was obtained with suitable criteria for use. Based on these results, math comics based on students' mathematical connection abilities were declared feasible and could be used in product trials on students.

Questionnaire answer criteria for students' responses to the attractiveness of the development of mathematical comic learning media products based on the mathematical connection ability of class VIII students in statistics material get a total average of 3.18 which is included in the attractive criteria.

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