Development of Math Comic Learning Media on The Subject of Algebraic Expressions for Seventh Grade of Junior High School Students

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Abstract. This development research aimed to 1) know the development process of mathematical comic learning media on the subject of algebraic expression that was valid, practical, and effective for grade VII of Junior High School students, 2) obtain mathematical comic learning media on the subject of algebraic expression which was valid, practical, and effective for grade VII of Junior High School students. The development model was using a modification of 4-D development model from Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel became a 3-D development model. The procedure of this development consisted of three stages, namely 1) define, 2) design, and 3) develop. The results of this study were 1) The process of developing comic learning media that was valid, practical and effective was found. 2) The mathematical comic learning media products on the subject of algebraic expression that was valid. From the validity data analysis, a validity of learning media score is 3,3 , lesson plans obtain a validity of lesson plan score is 3,66. a validity of knowledge assessment instrument score is 3,46, a validity of the students’ responses questionnaire score is 3,84. 3) The mathematical comic learning media products on the subject of algebraic expression was practical with practicality score is 3.3214 and 4) The mathematical comic learning media products on the subject of algebraic expression was effective were obtained. The products produced were two comic books with the subject of introduction to algebraic expressions and addition, subtraction and multiplication operations of algebraic expressions. The subject was presented in the form of stories with illustrations of black-and-white images and was equipped with practice questions.

1. Introduction
Comics are visual media in pictorial form. One of the comic genres that dominate in Indonesia is Japanese comics called manga. Manga began to be well known in Indonesia since early 1990s [1]. Now the number of manga enthusiasts in Indonesia is growing rapidly [1]. The children's interest in comics is quite large. Based on the data, the preferred comics in Indonesia, in [1], there are 81% of teenagers and children who prefer Japanese comics, 18% like American comics, and the rest like European and Indonesian comics. Besides manga, Indonesian comics were victorious in 1960s and 1970s, and even called as the golden age for Indonesian comics [2]. Then based on [3] the survey on children's interests and habits toward manga to 100 respondents, it was found that since the age of 7-8 years the respondents had read manga, as many as 36 respondents had 31-35 comics books, 55 respondents had 1-10 comics books and the number of manga that they had read in the last three months was 16-20 comics.
Tilley (in [4]) said, while reading comics can never approach the complexity of reading ‘real’ texts, “compared to reading ‘real’ books, reading comics appears to be a simple task and compared to reading no books, reading comics might be preferable”. Comics are not only used as entertainment media, but it can be used as learning media. One example of comics learning media in Indonesia is "Why" comic series. Topic in “Why” comic series is various, for the example, world famous figures, natural knowledge, social knowledge, mathematics, technology, economics, culture and many more. In particular topic mathematics in “Why” comic series, there are many subject in mathematics, for example, Fraction dan Decimals, Numbers, Geometry, etc.

One of the subject that can be presented in comics form is algebraic expression. The algebraic expression is important to be studied because algebra is used in everyday life. The algebraic expression has an important role to other concepts in mathematics. The algebraic expression is also used to describe the relationship between structures in mathematics.

Based on the data from Trends In International Mathematics and Science Study (TIMSS), an assessment about the trend of learning mathematics and natural science where algebra was included in the subject being tested showed that Indonesia ranked 38 in 2011, with a score of 386 below the average international score [5].

Based on the explanation above, it is necessary to do a research on the development of mathematical comics learning media on the subject of algebraic expression for grade VII of junior high school students. This study aims to 1) Know the development process of mathematical comics learning media on the subject of algebraic expression which is valid, practical, and effective for grade VII of junior high school students, 2) Obtain mathematical comics learning media on the subject of algebraic expression which is valid, practical and effective for grade VII of junior high school student.

2. Method

This research was a development research with a development model modifying 4-D model from Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel. This development model modification eliminated the disseminate stage. The procedure of this development consisted of three stages namely: 1) define, 2) design, and 3) develop.

Define stage aimed to decide and define the requirements needed in the development of comics learning media. Define phase consisted of five steps of activity namely initial – final analysis, students analysis, concept analysis, task analysis, and specification of learning objectives. In initial-final analysis, an analysis on the problems and difficulties in learning algebraic expressions was carried out through interviews with teachers, observation during internship program (PPL), and literature study. In student analysis, a study of students’ characteristics was conducted. Furthermore, concept analysis namely analyzing the concept of subject from various learning sources to formulate and systematically compile the concept of the subject that students would learn was conducted. After that the task analysis was done by formulating the main skills and tasks that students would do in learning. At this stage an analysis of core competencies, basic competencies and indicators of competencies achievement was carried out. The final step in define stage was the specification of learning objectives, namely the activity of formulating learning objectives that had to be achieved by students.

Design stage was the design stage of comics learning media, so that the initial comic design was obtained. Design stage consisted of four steps of activities namely test preparation, media selection, format selection, and initial design. The first step was test preparation which was making a test to assess the score of student learning outcomes after using comics learning media. The test was based on the learning objectives that had been formulated in define stage. Then the second step was media selection which was determining the right media for presenting the subject. In this step, media selection had been determined from the beginning namely comics. Then the third step was format selection namely the activities steps including the selection of learning strategies, learning approaches, learning methods, learning resources, and content design. Then the final step was the initial design. It was all activities that had to be carried out before the trial was conducted. At this stage an initial
design of comics learning media, lesson plan, knowledge assessment instruments, validation instruments and students’ responses questionnaires was made.

Develop stage aimed to produce comics learning media and the learning tools that completed it (lesson plan and knowledge assessment instruments) which had been revised based on the expert assessment and field trial. Develop stage consisted of two steps of activity, namely expert assessment and field trial. Expert assessment was an activity step which included validation test of all learning tools that had been made at the design stage which consisted of the initial design of comics learning media, lesson plans, knowledge assessment instruments, and students’ responses’ questionnaires to expert validator and practitioner. The expert validator was a mathematics lecturer, while practitioner validator was a mathematics teacher. Then field trial was an activity step that aimed to obtain input from the field on the comics learning media that was developed and to know the practicality and effectiveness of the comics. The field trial was conducted for nine students of grade VII of MTs Al Huda Sawojajar, Malang. Data obtained from expert assessment and field trial were then analyzed using data analysis technique for validity, practicality and effectiveness of [6]. Furthermore, comics learning media were revised based on suggestions and comments from experts and trial subjects.

3. Result
Comics learning media produced consisted of two A4-sized books with black-and-white illustrations. The first book was about the introduction of algebraic expressions, while the second was about the addition, subtraction and multiplication of algebra operations. The content format of comics learning media consisted of cover, media usage instructions, character profile (character), intro (introduction) character story, table of contents, learning objectives, subject (comic content), practice questions, and bibliography. Subject was presented in the form of daily life stories from comic characters.

The process of developing comic learning media used 3-D development model, which consisted of three stages: define, design, and develop.

3.1. Define
Define stage consisted of five steps: initial-final analysis, student analysis, concept analysis, task analysis, and specification of learning objectives.

In initial-final analysis it was obtained that students experienced a difficulty in translating sentences into algebraic expressions and a difficulty in performing addition, subtraction and multiplication of algebra operations.

After knowing the problems and solutions that could be done, then student analysis was done. In student analysis, it was obtained the result that the level of cognitive development of junior high school students was the transition from the concrete operational stage to the formal operational stage. It was also found that students’ understanding of the pre-requisite subject, namely operations on integers, was still low, but students’ interest in comics was quite big.

In concept analysis, the subjects that would be presented in comic were

- Introduction of algebraic expressions (examples of algebraic expressions in the real world and elements of algebraic expressions).
- Operations of addition and subtraction of algebraic expressions (examples in the real world, rules of operation, and the nature of the addition operation of algebraic expressions).
- Operation of algebra multiplication (examples in the real world, rules and nature of algebra multiplication operation).

In task analysis, the results were

- Focus core competencies on achieving competencies in knowledge and skills, namely KI 3 and KI 4.
- Basic competencies in algebraic expression, namely:
  KD 3.5: Explaining the algebraic expression and doing operations on algebraic expressions (addition, subtraction, multiplication, and division).
KD 4.5: Solving problems related to algebraic expressions and operations in algebraic expressions, and indicators of competencies achievement.

- Indicator of competencies achievement.

In this step the results of the formulation of learning objectives were obtained based on indicators of competencies achievement.

3.2. Design

The next stage was design stage. This stage consisted of four steps of activities namely test preparation, media selection, format selection, and initial design. Based on the initial-final analysis, the chosen media were comics. The approach used in learning with comic media was a scientific approach with learning models is modification of cooperative learning model, guided discovery, and realistic mathematics learning. The presentation design of subject was from easy to difficult and from real to abstract. The format of the contents of comic learning media was cover, media usage instructions, character profile, intro story: character recognition in the comic, table of contents, learning objectives, subject (comic content), practice questions, and bibliography.

In this step, an initial design of comic media, lesson plans, knowledge assessment instrument, students’ responses’ questionnaires, and learning tools validation instrument were obtained. The process of making comics was as follows:

- Synopsis
  Making a synopsis that contained the essence of the story to be conveyed, completed with a plot (storyline). The synopsis was complemented by themes, characters and description of the nature, and setting.

- Script (storyline)
  Before creating a script, panel standard format to be used was determined. The manuscript contained details about the order of panels, illustration of images, sound effects (if any), narrative text (if any), and dialogues of characters. These details were made for each page.

- Visual character.
  Making visual characters visually; a good character's visual character is if we can distinguish one character from another just based on the silhouette image. The visual character in this comic used a hairstyle as a characteristic and differentiator from one another.

- Comic Sketch (Storyboard)
  First, making a border for the confining area, which was 3 cm from the left, 1 cm from the top, 1.5 cm from the bottom, and 1 cm from the right for the odd pages, while the even pages were the same, but they were 3 cm from the right and 1 cm from left. Sketches were created manually with pencil on paper. The panel selected was a conventional box-shaped panel with a firm line. Picture illustrations were in the form of cartoon illustrations. The comic sketch was a visualization of the script.

- Inking (inking)
  It was thickening the manual comic sketch with drawing pens or markers so that the results when scanned were clearer. The parts that were not inked were only parts of the text because it would be typed digitally later.

- Scanning the inked sketch
  The sketches that had been inked could be scanned or photographed to get image files. Next, editing this image file would be done with Adobe Photoshop application.

- Digital sketch thickening
  In this step, editing sketch image files was with Adobe Photoshop application to make them clearer and better.

- Word balloon
  In this step the word balloon editing was done with Adobe Photosho application as well as typing the text. The word balloons used in this comic were speech balloon, mind balloon, and caption.
3.3. Develop

The last stage was develop. This stage consisted of two steps, namely the expert assessment and field trials. Based on the analysis of the data from the expert assessment, comic learning media is valid. From the validity data analysis, a validity of learning media score is 3.3, lesson plans obtain a validity of lesson plan score is 3.66. A validity of knowledge assessment instrument score is 3.46, a validity of the students’ responses questionnaire score is 3.84.

3) The mathematical comic learning media products on the subject of algebraic expression was practical with practicality score is 3.321. It was included in the valid criteria with the information that it did not need to be revised, lesson plans is also valid. It was included in the valid criteria with no revision, instrument knowledge assessment is valid. It was included in the valid criteria with information that it did not need to be revised, and students’ responses questionnaires is valid. It was included in the criteria of high practicality with information no need to revise. Then the results of effectiveness testing through knowledge assessment instruments found that 88.89% of students had fulfilled learning completeness.

4. Conclusion

The problem raised in this development research is that students’ understanding on algebra is still low, whereas algebra subject is important to learn. A solution offered to overcome it is by developing learning media in the form of comics. This is based on the use of comics today that are not only used as entertainment media but they are also used as learning media. This is supported by the existence of several studies on the use of comics as learning media that have been proven as effective media in learning. Therefore, this development research aims to 1) Know the process of developing mathematical comic learning media on the subject of algebraic expression that is valid, practical, and effective for grade VII of junior high school students, 2) Obtain mathematical comic learning media on the subject of algebraic expression that is valid, practical, and effective for grade VII of junior high school students.

From the description of the results, it is known that the process of developing comic learning media uses procedures from the 3-D development model, with the stages of define, design, and develop. In design stage namely in the format selection step, the learning model that will be used is adaptation and modification of the cooperative learning model, guided discovery, and realistic mathematics learning so that the subject is presented from realistic problems where students must solve it with the guidance of characters in the comic. Subject is designed from easy to difficult and from real to abstract. This is in accordance withPiaget's cognitive development theory, where grade VII of junior high school students are in the stage of concrete operational transition to formal operations [7]. As stated by [7] that junior high school mathematics teaching focuses on moving students from the concrete
operational stage to the formal operational stage. In addition, in the initial design process of comic learning media, there are steps that can be eliminated so that the manufacturing process becomes more efficient in terms of manufacturing time and energy. The step is inking comics. Comic learning media developed in this study, all of the contents are made digitally so that they are more clearly visible, clean and smooth illustrated images. Because the inking process is the same as the manual sketching process but using a drawing pen or marker, the sketching process is done twice, with pencil and drawing pen or marker. Therefore, the inking comics can be eliminated. However, if the comics to be created use manual sketch images for image illustrations (not digitally edited), then the inking process must be done so that the image illustrations are clear and good.

Then, at develop stage, the expert assessment and field trials are carried out. The expert assessment is a validation test for experts as the validator. From the validity data analysis, it is found that comic learning media obtain a validity score 3.3. It is included in the valid criteria with information that it does not need to be revised, lesson plans obtain a validity score 3.66. It is included in the valid criteria with no need for revision, knowledge assessment instrument obtained a validity score 3.46. It is included in the valid criteria with the statement that there is no need for revision. Then, a field trial is conducted to determine the practicality and effectiveness of the comic learning media developed. The practicality data analysis, it is obtained that the result of practicality score reaches 3.3214. This is consistent with the practicality criteria adapted and modified from [6] that if the practicality score reaches , then it includes a high practicality criterion with no need for revision. As for the effectiveness of the data analysis results, it is found that 88.89% of students achieve mastery learning. It is in accordance with the data analysis of the effectiveness of [6] that the learning media is said to be effective if at least 80% of all test subjects (students) fulfill the learning completeness.

The comic learning media developed are included in the category of image and text-based media. It is in accordance with the multimedia definition by [8] namely the media of images and text. Mayer's multimedia learning is based on the two channels cognitive development theory, where students absorb information with two channels (visual and auditory, verbal and nonverbal) so that the subject presented in the form of images and text makes the absorption of information more maximal and effective than when it is presented in the form of text or images only. This supports the effectiveness and practicality of comic learning media developed in this study.

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