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The Development of Investigative Learning Materials Using Computer Assisted Instruction in the Topic of Reflection for Grade VII

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Abstract. *Despite its importance, there are still many problems encountered in the learning of the topic of reflection in school. One of the solutions for these problems is the implementation of learning approaches that fit the modern curricula and the development of good quality instructional materials. Therefore, the aim of this study was to describe the quality of investigative instructional material with computer assisted instruction for the topic of reflection in Grade VII. The result of the analysis suggested that the investigative instructional material for the topic of reflection in Grade 7 is of good quality because it fulfills the following criteria: (1) the teacher was capable to manage the lesson well, (2) the students were actively involved during the lesson, (3) the students gave positive response to the instructional material, (4) the achievement test is valid, reliable, and sensitive; and (5) the validator claimed that the developed instructional material is valid.*

Keywords: *learning materials, investigative approach, computer assisted instruction*

Introduction

Computers have important roles in education. The role of computers is in accordance to the history ofcomputer usage in education.the history of the use of computers in education can be divided into two periods, namely the period before and after microcomputer was introduced. In the period before the introduction of microcomputer, precisely in 1950, the computer was first used in the learning process. After twenty years, microcomputers were introduced and played a huge role in the changing use of computers in education. The biggest change in the use of computers in education occured when World Wide Web (WWW) was introduced, which transforms the internet that originally was text-based only into text-and-image-based.

Based on the history of the use of computer in education, it can be said that computers has a very important role in education. The Center for Applied Research in Educational Technology (CARET), a project funded by ISTE (International Society for Technology in Education), outlines some of the benefits of the use of computer in education (Roblyer & Doering, 2009). The advantages of computer usage include (1) improving student learning outcomes; (2) developing problem solving skills and higher order thinking of students; (3) increasing students' interest, attitude, and motivation in

learning; (4) helping students prepare themselves in the job market; and (5) assisting students with physical or mental disabilities.

The advantages of computer usage described by ISTE are reinforced by Gross and Duhon (2014). Gross and Duhon stated that Computer-Assisted Instruction (CAI) can improve the students' learning outcomes. Furthermore, Brown, Lewis, and Harcleroad (2008) added that CAI can improve the students' problem solving abilities, while Hussain and Ali (2012) stated that the use of CAI can increase students' interest in learning. In addition, CAI can improve students' memory of the subject matter. In addition, CAI can also prepare the students in the job market (Cradler, McNabb, Freeman, & Burchett, 2002). This is because, when students learn to use some computer software, indirectly they have acquired the prerequisite skills to enter the workforce.

The CAI, which has many of those advantages, can be used as a tool for teaching and learning mathematics in secondary schools, especially in geometry. National Council of Teachers of Mathematics (2010), defines geometry as "a branch of mathematics that relates to the measurement, properties, and relationships of points, lines, angles, areas, and space; In general geometry is a study of the properties of given elements that remain invariant when subjected to a particular transformation." In Kurikulum 2013, there are twenty-two basic competencies related to geometry which spread from grade VII to IX. This amount is nearly one-third of the total junior high school basic competencies in the Kurikulum 2013. Thus, it can be said that geometric competences are important to be mastered by junior high school students.

The two geometric competencies that the junior high students must master are understanding the concept of transformation (dilation, translation, reflection, rotation), using geometric objects and applying transformation principles (dilation, translation, reflection, rotation) in solving real life problems. Based on the two basic competencies, the topic of reflection is one of the topics that must be mastered and understood by the students. The reflection is very important for other geometric transformation topics. This is because rotation, one of the other transformation topics, can be seen as the composition of some reflections on the condition that the reflection axes intersect at one point. Similarly, translation or shift can be viewed as a reflection composition against two parallel axes.

In addition, the topic of reflection is important for concepts in physics as well, especially in describing how optical devices work by the properties of reflection and refraction of light by mirrors and lenses. The reflecting properties obtained in grade VII is expected to assist students in studying the topic of the optical instrument to be studied in grade IX and X. If students already have a good understanding of the reflection properties in the geometric transformation, they will be easier to learn the concepts of reflection and refraction of light in the topic of optical tools.

Along with the many geometric competences that must be mastered by students, recent studies show that many students experience difficulties in learning geometry. As disclosed by Halat, Jakubowski, and Aydin (2008), many students experience difficulties in learning geometry. As a result, the students' learning outcome in geometry is very low. In addition, Ozerem (2012) revealed that many students are still experiencing misconceptions in geometry. This is happened because the teachers still prioritize oral presentation techniques in explaining the concepts of geometry to their students. As a result, students must see, listen, write notes, and think in the learning process. They must pay attention to the many elements of learning and put it into their memory. This often cause their thinking process become excessive and can cause negative effects on the learning process undertaken by these students.

Many researchers have experimented with a variety of teaching methods in geometry learning and found some problems experienced by students. These problems include the error of modeling a problem into its mathematical symbols, proof that are only based on geometric images (Healy & Hoyles, 2000), not mentioning the underlying propositions in the proof of a mathematical statement, etc. These problems can arise because the teaching and learning of geometry is often more complex than numerical operations or elementary algebra. Hence, the teaching and learning of geometry should employa tested learning approach accompanied by the use of multimedia learning aids.

More specifically, errors are also often done by the students in solving geometric transformation problems. Ozerem (2012) states that the students often make mistakes in getting information in questions that are descriptive. For example, when the students are asked to describe a transformation, they do not use specific words, such as translation, reflection, rotation, or dilation. In addition, the students also experience errors when asked to zoom in or out of a geometric object, and they use the coordinate plane in the wrong way. In addition, Ryan & Williams (2007: 21) revealed that the students also often experience misconceptions in the reflection.the Students often experience errors when identifying the reflection axis. the Students often assume that the reflection axis is one of the vertical lines, the horizontal line, the line through the side of a shape, or at least a line that parallel to the segment of the shape. Therefore, Ozerem (2012) recommends the use of CAI-based exercises so that the students can gain a better understanding in the topic of geometric transformation.

The use of CAI in the teaching and learning geometry, especially in the topic of transformation, that recommended by many researchers is supported by three functions that can be done by CAI. The three functions are simulation, tutorial, and drill-and-practice functions. The CAI's simulation function can show and demonstrate the basic concepts of transformation. Because of this function, students can easily learn the processes and see the geometric objects. For example, students can visualize how to reflect geometric objects in the coordinate plane. This kind of visualization can guide students to determine the properties of reflection.

The second CAI function is the tutorial function. With this function, CAI can act as a human tutor by providing all the information and learning activities needed for students to master certain topics, such as summaries, explanations, exercises, feedback, and assessments. In the topic of transformation, the function of this tutorial can be used to provide any material information that can be called at any time by teachers or students in a lesson. For example, if some students forget the properties of reflection, the teacher can easily recall the concept without writing it back on the board.

The third function of CAI is drill-and-practice function. Drill-and-practice function can be used by students to work with exercises or problems and they can get feedback directly. With this function, the students can practice to work with problems in transformation. the Students will easily know whether their answers are right or wrong. If their answers are false, the CAI can directly provide students with the answerk key

The effect of CAI in learning outcomes is of course related to how CAI is used in learning situations. Thus, the selection of learning approaches in constructing learning scenarios involving CAI is crucial to achieve the learning objectives. Teachers must choose a method that can create a meaningful learning for students. Lang & Evans (2006) revealed that the application of indirect learning methods can create a meaningful learning for students. This is because students play a direct role in obtaining and finding their own knowledge through learning activities.

One learning approach that emphasizes more on the use of indirect teaching methods is the investigative approach. The investigative approach has several advantages

when applied in mathematics learning. Quinell (2010) reveals that the investigative approach will maximize the use of the various skills and mathematical concepts that students have. In addition, implementation of investigative approach will strengthen the students' "mathematics language". This approach often includes the process of collecting, organizing, and analyzing information, as well as planning and organizing procedures to be performed. All these skills will help students to integrate several areas in mathematics.

Another advantage of the investigative approach is that the approach can be used to maintain an informal atmosphere in the classroom. Such an informal atmosphere can encourage communication and debate among students. Investigative activities can introduce valuable classroom collaborations and debates that are useful for students to exchange ideas with others.

In an investigation, students are given the opportunity to apply the mathematical knowledge they have to solve the problem as they perform the investigative stages. The student-centered investigative activity, in which students play an active role in learning, is a very common element in the modern mathematics curriculum. Mathematical investigations can be used to improve students' curiosity and exploration. This is because during the investigation process, students are required to think and not just follow certain steps. As a result, the student's understanding of the concepts will deepen.

Investigative activities will improve the students' ability to question since, in general, the activity contains the open-ended tasks that allow students to decide for themselves the maximum limit in solving a given problem. That is, the open-ended characteristics cause the same investigative activities that can be used for a wide variety of students with different mathematical skills.

Based on the advantages of CAI and the investigative approach already described, and various problems in the learning of geometric transformation, the investigative approach accompanied by computer learning media is suitable to be applied in the geometric transformation teaching and learning in grade VII. However, in terms of practicality, these two things are considered less practical to apply to the learning of geometry transformation. Therefore, it takes some other learning materials to be used by the teacher as a guide in conducting the learning process. The learning materials are lesson plan, computer-based learning media, worksheet, quiz, and process assessment.

Research Methods

This study uses a modified 4-D model from Thiagarajan, Semmel, and Semmel (1974). By using this model and the process of learning materials development is done through three stages, namely the define, design, and develop. In addition, the computer-based learning media was specifically developed according to Luther's model. Luther development model consists of six stages: concept, design, material collecting material, assembly, testing, and distribution (Sutopo & Hadi, 2003).

The author chose to develop computer-based learning media with different models from other learning materials in order to get detail process. In addition, this computer-based learning media development model is placed at the design stage in the 4-D model.

Subjects in this study were students of grade VII-D SMP Katolik Widyatama Batu. The class consists of 9 male students and 12 female students. Researchers choose the subject in the school because this school implements Kurikulum 2013, which is the foundation of authors in developing learning materials. Most of the students who were the subject of this study came from families with an average economy.

In this research, the instrument used to collect data is validation sheet, teacher and student observation sheet, questionnaire, and quiz. A validation sheet is used to obtain data about expert validation results on the learning materials. The expert validation sheet

consists of a lesson plan validation sheet, worksheet validation sheet, a computer-based learning media validation sheet, quiz validation sheet, and process assessment validation sheet. The validation sheets are filled by the validator to assess the learning materials. The assessment consists of 5 categories, that is not good (score 1), less good (score 2), good enough (score 3), good (score 4), and very good (score 5). The observation sheet is used to obtain data about the learning process. This observation sheet consisted teachers' ability to manage learning, students' activity, performance, and attitude assessment. Questionnaires are used to collect information about students' responses about instructional materials. The questionnaires are given to the students at the end of the learning process.

The data obtained from experts' validation for each learning materials is analyzed by taking into account the score, suggestions, feedback and comments from the validators. The results of these analyses serve as a reference for revising the learning materials. Learning materials that validated by validators are valid if the score on every aspect given by the validator at least in good category, namely 3,50 from a maximum score 5,00.

The data of the observer's assessment about the teacher's ability in managing learning process will be analyzed. The results of this analysis were obtained by calculating the average score for each observed aspect. The ability of the teacher in managing learning is said to be good if every aspect in lesson plan is at least in good category, i.e. at least 3,50 of a maximum score 5,00.

The data of students' activity is analyzed by using the ideal time percentage. Student activity in learning is said to be effective when the time used to perform each aspect of activity in accordance with the time allocation contained in each lesson plan with a tolerance limit is 10%.

Assessment of the learning process is done by taking and analyzing data on the average score of students' skills and attitudes in one group, called focus groups, during the lesson. Students' skills in learning are said to be good if the average score of students' skills is at least B-. While the attitude of students in learning is said to be good if the average value of student attitudes categorized at least B (Good). The learning process is said to fit in both criteria if the skills and attitudes of all students in the focus group are good.

The data of questionnaire were analyzed by calculating the percentage of the number of students who responded positively in each category against the number of all students who were subjected to the trial of the learning materials. Students' response is said to be positive if at least 75% of students choose the statement of happy, interested, or yes for each aspect listed in the questionnaire.

Validity of quiz item is done by using product moment correlation. A quiz item is said to be valid if the coefficient is at least moderate, or with a coefficient greater than 0.40. To determine the reliability coefficient of the quiz, author used Alpha coefficient. The quiz is considered to be reliable if the reliability coefficient is interpreted to be at least sufficient, or with an alpha coefficient greater than 0,40. While sensitivity coefficient is used to know how well the test items that can distinguish between students before receiving the learning with after receiving the learning. The criterion used to state that an item is sensitive is at least 0,30.

Results And Discussion

Table 1 shows the evaluation result of the learning materials developed in this study. Aspects that are seen to assess the quality of learning tools are expert validation, the ability of teachers to manage learning, student activities, student responses, quiz, and process assessment.

Table 1. Achievement of Learning Device Criteria

No.	Aspect Category	Achievement
1.	Expert validation	Valid
2.	The ability of teachers to manage learning	Good
3.	Student activity	Effective
4.	Student response	Positive
5.	Daily Deuteronomy (UH)	Valid, reliable, and sensitive
6.	Process assessment	Good

In lesson plan validation, the minimum of average score given by the validator is 4,0 out of a maximum score 5.0 on every aspect. The average score is derived from the score given by three validators. Because the average score obtained on each aspect are more than 3,50 then it can be said that the lesson plan is valid.

Validation of computer-based learning media yields an average score at least 4,0 on every aspect. Unlike the other learning materials, validators in this computer-based learning media consists of six people, three of them are experts in learning material and the others are expert in media. Because the average score obtained more than 3,50, it can be stated that computer-based learning media is valid.

In the worksheet validation, the minimum of average score was 4,0 in every aspect of the assessment. Therefore, the worksheet is categorized as valid.

In quiz validation, three kinds of data are obtained from each item, namely the validity of content, language, and writing, as well as recommendations from the validator. In terms of content validity, all validators state that every item in quiz falls within the valid criteria. Furthermore, the language and writing of each item in the quiz is clear. Additionally, all validators recommended that each item can be used with small revisions.

In process assessment sheet validation, the average scores given by the validator are at intervals between 4,0 and 4,7. This means that the process assessment sheet is valid. There is one validator who believes that the process assessment sheet can be used without revision, while the other two validators assume that the process assessment sheet can be used with small revisions.

Based on observations made by two observers, the ability of teachers to manage learning in every aspect in the three meetings has a minimum average score 4.0 that fall within good category. Therefore, it can be concluded that the level of teacher ability is good. This shows that most of the learning activities are in accordance with the lesson plan.

In addition, based on observations of student activities conducted by one observer in three meetings indicated that students' activities in every aspect at each meeting is still fall within the limits of effective criteria, i.e. with a tolerance of 10%. This shows that the students' activities in the teaching and learning with investigative approach is said to be effective.

Based on the students response questionnaire, it was found that students' responses to all aspect fall between 85% and 100%, so the students' response in the learning was positive.

Implementation of pre-test and post-test yields the validity, reliability, and sensitivity level of quiz. The validity of quiz items is shown by Table 2 below.

Table 2. Validity of Quiz Items

No.	r_{xy}	Interpretation	No.	r_{xy}	Interpretation
1	0,42	Medium	6	0,66	High
2	0,65	High	7	0,53	Medium
3	0,68	High	8	0,42	Medium
4	0,41	Medium	9	0,42	Medium
5	0,63	High			

Based on Table 2, it can be seen that the validity of quiz item has a coefficient that fall between 0,41 and 0,68. hence, it can be stated that all the items are valid.

The result of the quiz reliability calculation states that the reliability of the quiz items is 0,69 that fall into the high category. This means that the quiz items can be said to be reliable. The sensitivity of each item is shown by Table 3 below.

Table 3. Sensitivity of Quiz Items

No. Question	Sensitivity	Criteria
1	0,39	Sensitive
2	0,41	Sensitive
3	0,42	Sensitive
4	0,60	Sensitive
5	0,43	Sensitive
6	0,51	Sensitive
7	0,62	Sensitive
8	0,64	Sensitive
9	0,52	Sensitive

Based on Table 3, it can be seen that each quiz item has a sensitivity in between 0.39 and 0.64 inclusive, so that each item is sensitive against learning. Thus, each item of quiz can be categorized as sensitive.

Assessment of the process gives the result that each student in the focus group has an average skill score at least B+ and the lowest average attitudinal score is very good. This means that when viewed from the focus group, the students' skills and attitudes has good criteria.

Learning Materials

The investigative learning materials in the topic of reflection for grade VII developed in this study include lesson plan, computer-based learning media, students' worksheet, quiz, and process assessment sheet. Based on the results of the validators'

assessment, in terms of format, content, and language, all learning materials are in good category and can be used with small revisions. This is indicated by the average validator assessment of lesson plan, computer-based learning media, students' worksheet, quiz, and process assessment sheet is at least 4,0.

Since the validation results of all learning materials has an average score of at least 4,0, it can be stated that the learning materials that have been developed already meet the criteria of a good learning materials and can be used for trial.

Computer-Based Learning Media

Computer-based learning media is intended as a tool for teachers in demonstrating the procedures and concepts of reflection to students. So, in the process of investigation, the students pay attention to the illustrations provided by the media then do it together with members of their group or individually.

This learning media is a multimedia developed using Adobe Flash Professional CS6 software and is compatible with the Windows operating system. This media includes materials and exercise questions in the topic of reflection for grade VII. The topics t contained in this media are: reflections against the *x*-axis, the line *y = k*, *y*-axis, the line *x = k*, the line *y = –x*, and origin.

Every topic in this media is based on an investigative approach that consists of four stages, namely specializing, conjecturing, justifying, and generalizing.

Figure 1. Specializing Stage on Learning Media

In the picture above, the role of the media is to guide and demonstrate the steps in data collection. After that, the media guides students to give guesses about the observed data patterns. This section can be shown in Figure 2 below.

Figure 2. Conjecturing Stage on Learning Media

After the student finds the conjecture the teacher asks the student to test the students' conjecture against the example given by the media and critical examples from the teacher.

	Kuadran I	Kuadran II	Kuadran III	Kuadran IV
Titik Asli	$A\,(1, 3)$	$B\,(-3, 2)$	$C\,(-5, -4)$	$D\,(3, -1)$
Bayangan	$A'\,(-1, 3)$	$B'\,(3, 2)$	$C'\,(5, -4)$	$D'\,(-3, -1)$

Figure 3. Justifying Stage on Learning Media

Finally, if the students' conjecture has been tested through the justifying stage, then the media can provide feedback on the conclusions found by students. This stage is called the generalizing. The generalizing stage in the media can be shown in Figure 4 below.

Figure 4. Generalizing Stage on Media

Teacher's Ability in Managing Learning

In the implementation of learning with investigative approach in the topic of reflection, teachers are required to convey the learning goals well. In addition, teachers also must be able to manage the class so that the stages of learning can be directed as planned in the lesson plan. The time organization should really be considered since each meeting have learning objectives that must be met. Therefore, whether the learning is success or failure, depends on classroom management by teacher. Based on observations on teacher's ability in managing learning, show that the level of teacher's ability in every aspect is in good category.

Students' Activities

The students activities observed in this study include: (1) listening/observing teacher's explanations actively, (2) understanding the problems on worksheet, (3) solving the problems or finding ways and answers individually, (4) expressing opinion/idea to teacher or friends in the group in the group discussions, (5) discussing/asking to partners/teachers, and (6) deducing a procedure or concept with their own words. The results showed that students' activity is effective.

Students' Response

Students' responses observed in this study is the response for the teacher presentations, animated illustrations used by teachers in the presentation, worksheet display, worksheet language, problems in worksheet, worksheet tasks in the group discussions activity, presentations, and the teacher guidance. In the trial phase on the development of the learning materials for grade VII, it can be concluded that the students' response is positive.

Conclusion

A Based on the analysis and discussion of the results of this study, we concluded as follows: Based on the development of learning materials by using modified 4-D model, learning materials with an investigative approach was produced. The learning material consists of lesson plan, computer-based learning media, student's worksheet, quiz, and process assessment sheet. After going through the expert validation and trial, the learning materials can be categorized as good quality.

Based on their conclusion, authors put forward some suggestions as follows, (1) Learning tools generated in this study can be used as an alternative learning materials with an investigative approach to teach the topic of reflection for grade VII, (2) For researchers that are interested in developing learning materials with an investigative approach, the results of this study can be used as a reference for future research.

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