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## THE DEVELOPMENT OF MATHEMATICS LEARNING INSTRUMENTS INTEGRATING MULTIPLE INTELLIGENCES ON TOPICS OF CUBOID AND CUBE FOR THE EIGHTH GRADE STUDENTS OF JUNIOR HIGH SCHOOL

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### **Abstract**

*This study is motivated by the theory of multiple intelligences which reveal that a student will be able to learn mathematics well, if it is delivered in accordance with the intelligence that matches with his/her intelligences. Because the intelligences of students in the classroom are diverse, teachers need to use a variety of ways so that the students can also be facilitated in accordance with the intelligences they have. Therefore, it is needed mathematics learning instruments integrating multiple intelligences. This is a developmental research that uses a model of Plomp development consisting of preliminary investigation, design, realization, and phase of the test, evaluation, and revision. The objectives of this research are to describe the process and results of developing mathematics learning instruments, as well as acquire it which integrates multiple intelligences on topics of cuboid and cube for the eighth grade students of Junior High School. The instruments were trialed on 25 students at grade VIII of SMP Negeri 1 Bojonegoro year 2010/2011. The results showed that the learning instruments are categorized as good learning instruments. The instruments consisting lesson plan, student's book, student's worksheet, assessment sheet are valid. They are also practical shown by the average of the experts stated that it can be used by little revision, and the average of learning implementation is categorized as a good implementation. They are also effective, shown by the student's activity of multiple intelligences involvement is effective, student's learning outcomes is classically successful, and student's response is positive.*

**Keywords:** *Mathematics Learning Instruments, Multiple Intelligences, Cuboid and Cube.*

### **INTRODUCTION**

Howard Gardner, a professor of Harvard School of Education has formulated the theory of multiple intelligences called multiple intelligence. In his book: *Frames of Mind* (1983), he mentions seven types of intelligences: verbal/linguistics intelligence, visual/spatial intelligence, logical-mathematical intelligence, musical intelligence, bodily/kinesthetic intelligence, interpersonal intelligence, and intrapersonal intelligence. Even in his last book, *Intelligence Reframed* (1999), he added two types of intelligences i.e naturalist intelligence and existential intelligence (Efendi, 2005: 140).

Each type of intelligence revealed by Gardner has unique characteristics. Verbal/linguistic intelligence is related to the ability of using and manipulating words effectively either orally or in writing. (Gardner in Suparno, 2004: 26). Meanwhile, logical-mathematical intelligence is related to the ability of using any reasons both inductively and deductively, solving abstract problems, and understanding the complex relations of things, concepts and ideas that are interlinked among one another (Bellanca, 2011: 2). Visual/spatial intelligence includes the skills of creating a graphical representation, mental images, three dimensional thinking, and create visual world (Efendi, 2005: 145).

Furthermore, musical intelligence is related to the ability of developing, expressing, and enjoying any forms of music and sound (Bellanca, 2011: 3). Bodily/kinesthetic intelligence is related to the ability of controlling and interpreting the movements of the body, setting up physical objects, and establishing a balance between body and soul (Bellanca, 2011:3). Meanwhile, interpersonal and intrapersonal intelligence respectively is associated with the person's ability to establish communication with various people and the ability of taking a personal decision. Lastly, naturalist intelligence is related to a person's ability to understand the flora and fauna well, understand and enjoy nature, and develop knowledge of the natural world (Bellanca, 2011: 4).

Basically, every student has those nine types of intelligences, but in different stressing. A student might be strong in some intelligences, but weak in the other types of intelligences. For instance, a student might be strong in kinesthetic intelligence but weak in logical-mathematical intelligence. Nevertheless, this weakness of the intelligences could actually be repaired through education. Education should help students to encourage each intelligence grows optimally. Therefore, learning activities conducted at school should be designed by considering a variety of student's intelligences. This idea is similar with Gardner's statement saying that although students are only dominant on some intelligences, they could actually be helped through education by teacher's help to develop other intelligences so that those can be used for life more comprehensively (Gardner in Suparno, 2004:15).

Based on the theory of multiple intelligence, a student can learn a lesson well when it is delivered according to intelligence that matches with his/her intelligence. For example, a student who is dominant in kinesthetic intelligence will be able to learn mathematics easily if it is taught and served in expression of physical movement. Because student's intelligence in the classroom variegated, teachers need to use various methods representing many kind of intelligences so that every student can be assisted according to intelligence they have.

In fact, the practice of learning in the classroom does not fully support the diversity of student's intelligence. Teachers tend to teach in accordance with the intelligence that stand out on him/her or according to kind of intelligence which are much involved in lesson being taught. For example, some mathematics teachers tend to deliver the lesson by asking students to solve any mathematical problems much abstractly which involve more logical-mathematical intelligence than other types of intelligence might be involved in learning, whereas Adams (2001) said, "Each child may use a variety of these intelligences to learn mathematics concept and skills, not just the logical-mathematical." Regarding this opinion, Gardner (2003: 29) states that the most

important thing in learning practices is that teachers should be able to recognize and preserve the diversity of students' intelligence because they have different combinations of intelligences. By this way, every student will be more appreciated in terms of their intelligences so that they are motivated to learn any lessons.

Conducting mathematics learning integrating multiple intelligences, teachers need to think how a topic can be transformed into the form of intelligences as many as possible. Mathematical concepts and skills can be delivered in the form of written or oral language, pictures, musical expression, physical movement, social interaction, self-reflection, even natural world. This is in line with Armstrong's statement (2009:64) saying that the best way to approach curriculum using the theory of multiple intelligences is by thinking about how one can translate the material to be taught from one intelligence to another.

Integrating multiple intelligences into mathematics learning also needs instructional instruments, such as lesson plan, student's book, student's worksheet, and assessment sheet. All the instruments are expected to work simultaneously to support learning activities. In term of designing lesson integrating multiple intelligences, Armstrong (2009:65-67) gives idea of creating lesson integrating multiple intelligences as described below.

1. *Focus on a specific objective or topic.* This study focuses the topics of cuboid and cube talking about elements and properties of cuboid and cube, nets of of cuboid and cube, surface areas of cuboid and cube, and volumes of cuboid and cube
2. *Ask key MI (Multiple Intelligences) question.* The emerging questions should only ask on focused topic or learning objective which is put on the center like in the figure as an example below.

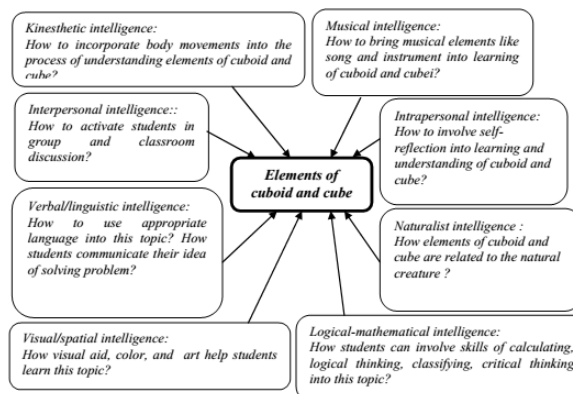


Figure 1. MI Planning Questions for the topic of elements of cuboid and cube.

3. *Consider the possibilities.* Make some schemes showing possible activities based on the figure 1. For instance, the possible activities to understand the topic of cuboid and cube written on the table below.

Table 1. MI Possibilities for the topic of elements of cuboid and cube

Intelligences	Possible Activities	Tools
verbal/linguistic	Restate the definition of cuboid and cube using personal language, use communication skill to present group's work result	Student's worksheet
logical-mathematical	Classify things around classroom included in the shape of cuboid or cube, then calculate the	Student's worksheet,

Intelligences	Possible Activities	Tools
	measurement of those elements	student's book
visual/spatial	Draw cuboid and cube and determine their elements, represent problems using picture/diagram	Colored pencil, ruler, student's book
Kinesthetic	Move to find out information about elements of cuboid and cube put on the walls in the classroom to solve problems given on the worksheet, hold <i>hands-on activity</i> to find out the properties of elements of cuboid and cube	Sheets containing information of cuboid and cube, cube units, worksheet,
Musical	Sing a song whose lyrics contains elements and properties of cuboid and cube	Student's book, speaker, laptop
Interpersonal	Work in group to discuss problem given in the worksheet	-
Intrapersonal	Write weakness, advantages and difficulties of understanding elements of cuboid and cube at the end of the lesson	Reflection card
Naturalist	Find some objects around the classroom which are in the form of cuboid and cube, then determine their measurements	-

4. *Brainstorm.* Think more possible activities which are appropriate with the topics in order to obtain many more intelligences which could be involved into learning activities.
5. *Select appropriate activities.* Choose several appropriate activities which mostly possible to conduct in the process of learning by considering the time needed.
6. *Set up a sequential plan.* Put the chosen activities in the right order which are then arranged into lesson plan. After that, write the tools required which could support learning process such as worksheet, student's book, and assessment sheet.
7. *Implement the plan.* Conduct the learning using lesson plan which have been created. The teacher can modify the learning process according to the student's feed-back.

From the description above, the researcher considered that it was important to develop learning instruments consisting of lesson plan, student's book, student's worksheet, and assessment sheet integrating multiple intelligences through the research entitled, "*The Development of Mathematics Learning Instruments Integrating Multiple Intelligences on Topics of Cuboid And Cube For The Eighth Grade Students Of Junior High School*". This study aims to describe the process and the result of developing learning instruments, and also obtain the learning instruments integrating multiple intelligences on topics of cuboid and cube.

### Method

This is a developmental research. The model of development used in this study is Plomp's model consisting of (1) preliminary investigation; (2) design, (3) realization, (4) test, evaluation, and revision (Khabibah, 2006). In this study, the learning instruments being developed (*lesson plan, student's book, student's worksheet, and*

assessment sheet) are categorized as good instruments if they satisfy aspects of validity, practicality, and effectiveness. Figure 2 below shows a flowchart of developing learning instruments.

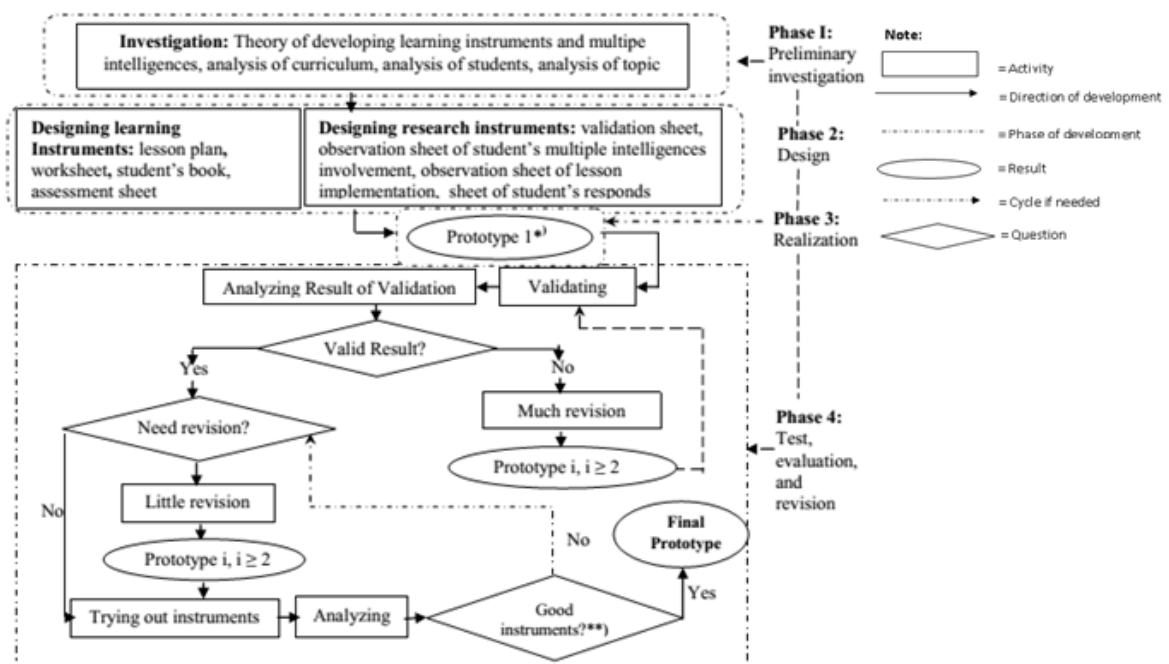


Figure 2. Flowchart of developing learning instruments

## RESULT AND DISCUSSION

### 1. Phase of Preliminary Investigation

Researchers used the framework of designing lesson integrating multiple intelligence from Armstrong (2009) and theory of Multiple Intelligences by Gardner (2003) as fundamental theory in developing learning instruments. Analysis of the students was done by examining the characteristics of students in accordance with the development plan of learning. Every student has some types of dominant intelligence to learn something. This potential is possessed by each student with a different range of intelligence. Hence, it requires a learning design involving intelligence as much as possible so that every students is facilitated to learn. For those who are weak in certain intelligence, the learning design is useful to develop other intelligences so that it will be useful for their thorough life.

Analysis of the teaching material was done by identifying the main parts of the teaching material of cuboid and cube will be learned. Learning indicators of this material are: (1) mention the elements and properties of cuboid and cube, (2) determine the measurement of cuboid and cube elements, (3) draw and determine the nets of cuboid and cube, (4) find a number of composition of cuboid and cube nets, (5) find the formula and determine surface areas of cuboids and cube, (6) solve problems related to the surface areas of cuboid and cube, (7) find the formula and determine the volumes of cuboid and cube, (8) solve problems related to the volumes of cuboid and cube (9) determine the volumes of cuboid and cube if the measurements are changed.

## 2. Phase of Design

There are two objects developed in this phase: learning instruments and research instruments like shown in figure 2. Lesson plans are designed in four meetings discussing: (1) elements and properties of cuboid/cube; (2) nets of cuboid and cube; (3) surface areas of cuboid and cube; (4) volumes of cuboid and cube. Lesson plan describes introduction, main activities, and closing for each meeting completed with the explanation of involved intelligences. Meanwhile, to give special features on student's book integrating multiple intelligences, there are some special features written in the book such as "*Word Smart*" (find out some mathematical terms in a box of puzzle to involve verbal/linguistic intelligence), "*Real-Life Math*" (solve problems represented the relationship between natural/daily life and cuboid/cube to involve naturalist and logical-mathematical intelligence), "*Critical Thinking*" (solve mathematical problems which supports critical thinking to involve logical-mathematical intelligence), "*Let's sing math song*" (sing a cuboid/cube song to involve musical intelligence), and "*Mapping Your Thinking*" (create *mind-mapping* as a diagram used to visualize outline learning of cuboid/cube to involve visual/spatial and intrapersonal intelligence).

Some features of multiple intelligences involvement in the worksheet are shown through a series of tasks which must be solved by students such as "*Writing Math*" (write verbal answer like giving any reasons to involve verbal/linguistic intelligence), "*Drawing Math*" (make representation of the answer like picture or diagram) and "*Visualizing Math*" (draw the flattened shape of cutting cuboid/cube as a result of visualization to involve visual/spatial intelligence), "*Life-Math*" (solve daily life problems to involve naturalist and logical-mathematical intelligence), and the other tasks which show the involvement of kinesthetic and interpersonal intelligences implicitly through the tasks such as holding *hands-on activity* and working in group. On the other hand, kind of assessment developed is written test which deliberately involves verbal/linguistic, logical-mathematical, and visual/spatial intelligences.

## 3. Phase of Realization

### 1) Lesson Plan

Some types of intelligences involved in activities are shown like below.

Closing			
Give reflection cards to the students and ask them to write down what they have learned in the lesson, what they feel and what benefits they might get	Write down the summary, difficulties, and the benefit of learning the lesson as a reflection to learn the next material	After writing reflection, teacher asks students to submit their cards, and give comments, then give it back in the next meeting	Intrapersonal Verbal/linguistic
			10

Students are asked to write self-reflection related to the lesson they joined at meeting 2. This aims to involve verbal/linguistic and intrapersonal intelligences.

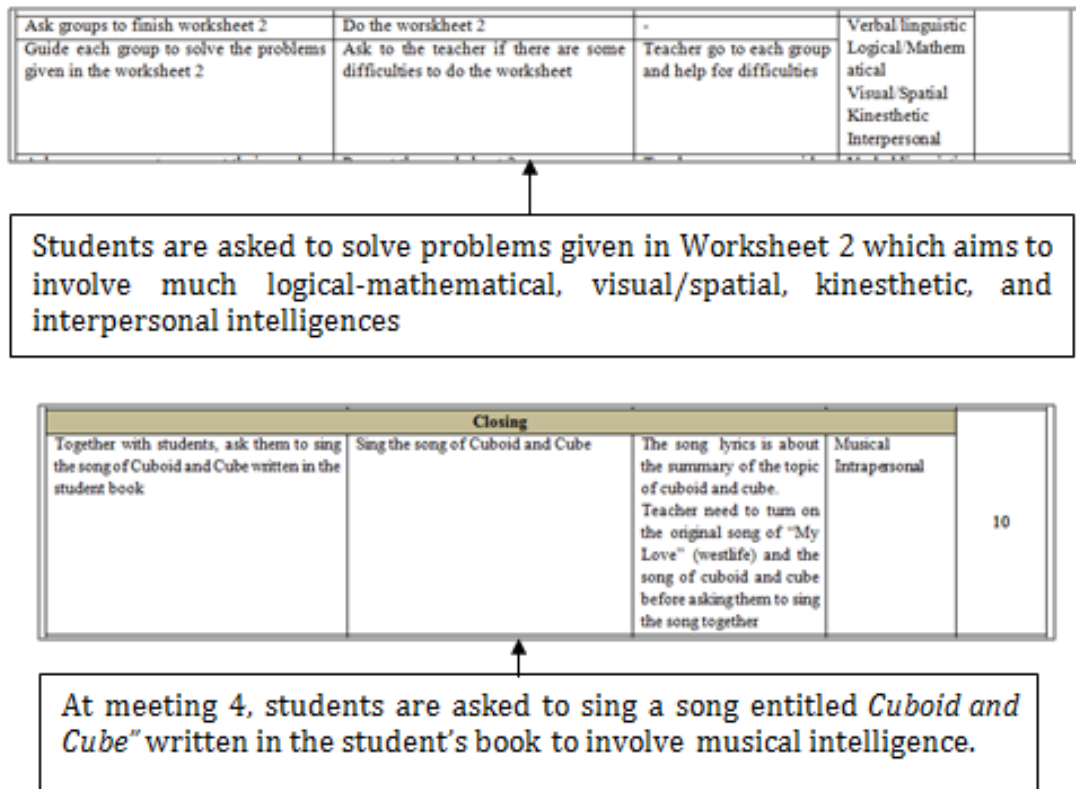


Figure 3. Prototype 1: Lesson plan

2) Student's Book

Some types of intelligences involved in the features in the student's book are shown like below.

**Real Life Math:**  
Naturalist and logical-math intelligences

**Critical thinking:** Logical-mathematical intelligences

**Word Smart:**  
Verbal/linguistic intelligences

**Let's Sing Math Song:**  
Musical Intelligence

Figure 4. Prototype 1: student's book

3) Student's Worksheet

Some types of intelligences involved in the tasks given to the students in the worksheet are shown like below.

Figure 5. Prototype 1: worksheet

4) Assessment Sheet

Some types of intelligences involved in the written test given to the students after meeting 4 are shown like below.

Figure 6. Prototype 1: Assessment sheet

4. Phase of Test, Evaluation, and Revision

In this phase, there are two activities conducted: validating learning instruments and trying out learning instruments to the research subjects. The description of those activities is given as follows.

a. Validating learning instruments

The instruments were validated by three experts consisting of two lecturers who focused on the mathematical content, appropriateness of the instruments to the



theory of multiple intelligences, and language used in the instruments, and a mathematics teacher who focused on the level of mathematical content and activities to the student's ability. The result of score of validation comes from the average score from those three experts and then it is classified into category based on criteria of validity on learning instruments by Khabibah (2006) as shown below,

$$4 \leq AV_{LI} \leq 5 : \text{vey valid}$$

$$3 \leq AV_{LI} < 4 : \text{valid}$$

$$2 \leq AV_{LI} < 3 : \text{less valid}$$

$$1 \leq AV_{LI} < 2 : \text{not valid}$$

**Note:**

$AV_{LI}$  = Average score of validity on learning instruments

A learning instruments is said to be valid if the average validity of instruments in criteria of valid or very valid. The result shows that the average values of validation given by experts to lesson plan is 3,96 (valid), student's book is 3,72 (valid), student's worksheet is 4,02 (very valid) for, and the average value of assessment sheet is 3,86 (valid).

Beside giving judgment, the experts also give advice on improvements to the instruments being developed. Here are some changes based on suggestions from the experts.

1) Lesson plan

Table 2. Changes of Lesson Plan based on Expert's suggestion

No	Type of suggestion	Revised Component of Lesson plan	Before revision	After revision
1	Appropriateness of involved intelligence in learning activities	Lesson plan 2 ( <i>Learning Activities</i> )	Student's activities: <i>Move to desk</i> (Kinesthetic)	Student's activities: <i>Move to desk</i> (No specific intelligence involved)
		Lesson plan 3 ( <i>Learning Activities</i> )	There have not been any explanation about involvement of naturalist intelligence in the activity of motivating students	There is an explanation of involvement of naturalist intelligence. <i>"One of motivation is how to minimize the paper used to wrap the food using the idea of surface area of cuboid in order to reduce the use of trees as stuff of paper"</i>
3	The clarity of learning activities	Lesson plan 1 ( <i>Learning Activities</i> )	<i>Do worksheet 1 in groups by carrying out some activities given in the posts. (Each group must move to other posts after doing the activity in certain post.</i>	<i>Carry out worksheet 1 in groups by carrying out some activities given in the post. (Each group must move to other posts after doing the activity in certain post; there are six posts; POST 1, POST 2, POST 3, POST 4, POST 5, and POST 6)</i>

No	Type of suggestion	Revised Component of Lesson plan	Before revision	After revision
		Lesson plan 1,2,3,4	There has not been a clear division between the learning activities written in the lesson plans	<i>There are three main part of activities : (1)Introduction, (2) Main Activities, (3) Closing</i>

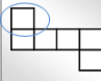
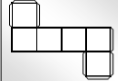
## 2) Student's book

Table 3. Changes of Student's book based on Expert's suggestion

No	Type of suggestion	Revised Component of student's book	Before revision	After revision
1	The balance of text and illustrations	Main content	Too many texted explanation, less supporting illustration	Some explanation is supported by pictures and diagrams
2	The use of mathematical term in English	Main content, exercises	Unsuitable mathematical terms are used in explanation and exercise	Precise mathematical term are used ,especially for the topics of cuboid and cube
3	Form of explanation	Main content	Some explanation seems do not involve much student's thinking, because they are too clearly served	Reduce explanation and transform explanation into the form of student's task carried out in worksheet

## 3) Student's worksheet

Table 4. Changes of Student's worksheet based on Expert's suggestion

No	Type of suggestion	Worksheet	Before revision	After revision
1	The appropriateness of used illustration	Main task (Worksheet 2)	3. Cut out the net. Then build the cube! 	Cut out the net like shown at right. Then build a cube using paper glue! 
2	The use of mathematical term in English	Main task (Worksheet 2)	Unsuitable mathematical terms are used in the task Ex: "Roll the cube on to another side. Continue tracing each side to make the figure as shown so that all sides of cube are traced!"	Precise mathematical term are used, especially for the elements of cuboid and cube Ex: "Roll the cube on to another face. Continue tracing each face to make the figure as shown so that all faces of cube are traced!"

## 4) Assessment sheet

No	Type of suggestion	Before revision	After revision
1	The type of question	Essay No 3 (Closed question):	Open-ended question: No 3 "Pak Qohar wants to build a swimming pool"

	<p>"Pak Qohar wants to build a swimming pool with blue color. A tin of paints could only be used for 1 m<sup>2</sup>. If the height, the width, and the depth of the swimming pool consecutively is 18 m, 8 m, and 2 m, and a tin of paints cost Rp20.000,00, how much is the cost needed by Pak Qohar to buy the paints?"</p>	<p>having a volume of 720 m<sup>3</sup>. He wants to paint the swimming pool with blue colour. A tin of paints could only be used for 1 m<sup>2</sup>.</p> <p>1. If Pak Qohar wants to build the height of swimming pool is not more than 3 m, what possible dimensions which can be chosen by Pak Qohar? (mention only two possible dimensions).Hint: (Dimension : a length, a width, and a height of swimming pool)</p> <p>2. If a tin of paints costs Rp20.000,00, how much is the minimum cost needed by Pak Qohar to buy the paints (Choose only a dimension that you found in 3a)"</p>
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#### b. Trying out learning instruments

In this step, the data of (1) learning implementation, (2) student's activities of multiple intelligences involvement, (3) student's learning outcome, and (4) student's responds are gained. Prototype 2 as results of validation was used in the class where the try out of instruments was trialed on.

One of criteria on practicality is learning implementation. The score of learning implementation comes from the average score from two observers observing learning activities in four meetings and then it is classified into category based on criteria of learning implementation by Khabibah (2006) as shown below.

$4 \leq LI_{LI} \leq 5$  : very good

$3 \leq LI_{LI} < 4$  : good

$2 \leq LI_{LI} < 3$  : less good

$1 \leq LI_{LI} < 2$  : not good

#### Note:

$LI_{LI}$  = Average score of learning implementation using the learning instruments being developed

Here, the learning implementation is said practical if it is in the criteria of good or very good. The results show that learning implementation is categorized as a good implementation based on average total of 3,95 (good). On the other hand, the total percentage of activity on involved multiple intelligence is 89,46%. It shows that multiple intelligences were successfully involved by students nearly all the time of learning so that the activity of students is said to be effective. In addition, student's score of learning outcome shows that 88% of students passed the minimum targeted score (75 out of 100). On the other hand, more than a half of items of questionnaire is categorized as strong responds. It can be concluded that the learning instruments obtain positive responds from the students.

## CONCLUSION

The development of learning instruments was conducted using Plomp's model of development consisting of phase of preliminary investigation, design, realization, and test, evaluation, and revision. Based on the analysis done on those phases, it can be concluded that the learning instruments satisfied aspects of : (1) *validity*, shown by

average total of validation given by experts shows that instruments are valid (lesson plan (3,96), student's book (3,72), worksheet (4,02), assessment sheet (3,86)); (2) *practicality*, shown by expert's review stating that the learning instruments are practical and average total of learning implementation in the classroom is 3,85 (good); and (3) *effectiveness*, shown by student's activities of multiple intelligences involvement is effective with percentage of 89,46%, student's learning outcome is classically successful (88% of students passed the minimum targeted score (75 out of 100)), and student's responds to the learning instruments is positive. Hence, the learning instruments which have been developed in this study is final prototype.

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