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Developing Learning Device on Environmental Pollution Topic in Senior High School

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Abstract: This study is intended to evaluate the validity, practicality and effectiveness of learning device development in accordance with environmental pollution in Madrasah Aliyah. What is meant by learning device is a syllabus, lesson plans, worksheets and key answers, assessment sheets and key answers as well as teaching materials. In this study, Mafumiko Model was chosen in order to determine the development measures such as expert opinion, small class and big class test and lastly, expert opinion through panel sessions. Moreover, this study used a descriptive quantitative research method in its implementation. The subjects of the research are three professors of biology, individual test (one to one) and a small class of students in first year class, also other field trials from different students in the other 2 classes. This study was carried out for 6 months (April-September 2015) and the data validity was obtained from the expert team decision conducted by using the format of learning device validation rating. In the other hand, the practicality data was generated from the observer point of view on the learning assessment implemented by teacher with lesson plan format. Meanwhile, the effectiveness data was derived from: cognitive tests, performance skills observation, psychomotor skills observation, spiritual attitudes observation, character observation, social attitudes observation, critical thinking skills test, student activity during learning activity observation and teacher activity during learning activity observation. Then, the analysis was established descriptively and it produced a valid, practical and effective result. The result showed teachers were capable in implementing the learning activities. Based on the efficiency parameters, this study showed that the learning device was in a good category.

Key words: Learning device, environmental pollution, development research, learning activity, skil observation, implementing

INTRODUCTION

Learning device in school needs to be evaluated and improved periodically through development research. Previously, the term of development research was popularized by Richey and Klein (2014) as design and development research that is a systematic study of the process, development and evaluation aimed to create a teaching or non-teaching product (device). The process of the research is a repeated design (iterative) that focuses on the implementation and development in the field of education (Rawson and Hassell, 2016).

The Design-Based Research (DBR) or other similar terms like design research, development research, design and development research has gained an attention from researchers (Amiel and Reeves, 2008). Rawson and Hassell (2016) described that DBR is developed over the last 2 decades in the field of education in which it offers a way to address both of these problems simultaneously by placing the research, design, practice and theories into real-world context. By its nature, DBR is relevant to the practice and its education policy as it aims to develop a research-based solution for complex problems in education practice or learning theory development and validation.

Plomp and Nieveen introduced 3 main types of design research. Development research aims: the validation study in which it is intended to develop/validate the theory and implementation study is to spread and apply the results of educational interventions. Based on clinical supervision, the learning device that is made by teachers in Madrasah Aliyah does not reflect the critical thinking skills. By that, the question of how valid, how practical and how effective the learning

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device that is derived from the development of environmental pollution in Madrasah Aliyah is proposed in this research.

The validity, practicality and effectiveness (high-quality intervention) is an indicator of the quality of products development. This is said to be valid (relevant) due to the intervention and the design that is based on scientific knowledge (state-of-the-art). Tessmer (1998) also explained in practical terms when the user is using the product in the learning environment easily. And then, this is classified as an effective thing when a goal can be sorted into a number of specific questions and criteria.

The teaching of environmental pollution could be more meaningful if students have an interaction with nature or the environment. Students will do investigations or observations of the symptoms such as the animal reactions against air pollution, water pollution and soil pollution. They are also able to do scientific work in which teachers would use learning model that facilitates students in their experiments. In here, inquiry model is considered to be relevant in providing an opportunity for student activity.

The development research of learning device has been reported by several studies (Mellawati, 2012; Usmiyatun, 2014; Lestari, 2012; Ayatus'adah, 2013; Soviarini, 2013). Similar, research which uses validity, practicality and effectiveness indicator has not been much reported by another study. Whereas, the development research is expected to improve the learning device through a formative evaluation as the core of the process. This study aims to evaluate the validity, practicality and effectiveness of learning device development in accordance with environmental pollution topic in senior high school.

MATERIALS AND METHODS

Mafumiko Model was used in this study because each stage (as illustrated in Fig. 1) is aimed to improve the quality of a prototype which acts as an indicator of development (Mafumiko, 2006). The learning device (Version 1) which has been prepared was assessed by the expert team first, revised subsequently and generated Version 2. After that this Version 2 learning device was tested in small classes and big classes. There were still some revisions on the device so that Version 3 was created. The revised learning device was examined by the specialist team again through panel sessions in which final revision was carried out and a prototype (Version 4) was produced.

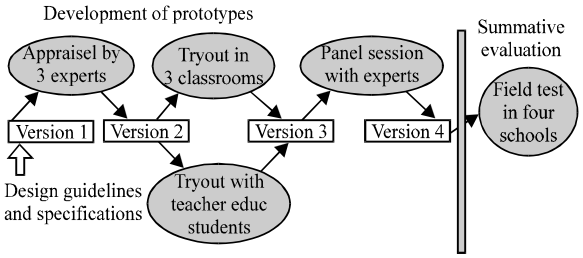

Fig. 1: Mafumiko research design (Mafumiko, 2006)

This study was implemented for 6 months (April-September, 2015) at a senior high school at Banjarmasin. The subject of the study which was intended to determine the validity of the learning device (expert appraisal and panel session) was 3 experts (professors of biology) who are active in the learning device validation field for the last 4 years. On the other hand, a subject of the small trial group (tryout with teacher and student) was used to establish the practicality (lesson plans implementation) which consisted of 10 students of Biology first grade in the school. Moreover, a subject of field trial (tryout with 2 classrooms) was carried out to evaluate the effectiveness of the device (Supiati, 2015) which consisted of 35 students (A class) and 33 students (B class). The effectiveness was determined based on the cognitive learning outcomes, psychomotor, spiritual attitude, character behavior, social attitudes, performance skills, critical thinking skills, student activities and teacher activities.

Learning device validity was gained from the expert opinion where it covers syllabus, lesson plans, worksheets and answer key, assessment sheets and answer key as well as teaching materials. In contrast, the practicality of the learning device was derived from the learning observations that were done by the teachers. Besides validity and practicality indicator, effectiveness was compiled from the results of the learning process as follows: cognitive tests, student's performance, psychomotor skills, spiritual attitudes, behavioral character, social skills, critical thinking skills, student activities and lastly, teacher activities.

Validity, practicality and effectiveness of the learning device were examined with the help of laboratory of science and mathematics school learning, State University of Surabaya (Nur, 2014). Validity instrument contains the assessment of syllabus, lesson plans, worksheets and answer key, assessment sheets and answer key as well as teaching materials while practicality instrument includes the learning scenarios observation. Different thing also happened in the effectiveness instrument in which it

covers: cognitive test materials, performance skills, psychomotor skills, spiritual attitudes, behavioral character, social attitudes, critical thinking skills, student activity and teacher activity.

The data analysis in this study confirmed the learning device validity by using 4 scale score (1 = less valid, 2 = quite valid, 3 = valid and 4 = very valid). Whereas, the final score was determined by the mode. The data analysis also set the practicality indicator with the range of 1-4 (1 = no teacher activity accomplished, 2 = implemented partly, 3 = mostly done and 4 = all done).

At the same time, the data analysis which was used to determine the learning device effectiveness were the cognitive learning outcomes based on the correct answers and referred to the Minimum Completeness Criteria (MCC) (with minimum score at 2.67), performance skills, psychomotor skills, spiritual attitude, characters, social attitudes, critical thinking skills derived from the worksheets as manifestations of inquiry model steps, student activity and teacher activity. In addition, all data in this study were analyzed descriptively.

RESULTS

Learning device validity: Expert opinion was considered as a validity indicator of the study in which it was presented in Table 1. Based on Table 1, the expert team believed that the learning device was already valid without any revision. Therefore, the small trial group was conducted.

Learning device practicality: The implementation of lesson plans was seen as a practicality indicator like in this following Table 2. Table 2 showed that teachers were able to carry out the learning activities and that learning device was practical to be used.

Learning device effectiveness: The effectiveness indicator of learning device was based on cognitive learning outcomes, performance skills, psychomotor, spiritual attitude, character, social skills, critical thinking skills, student activity and teacher activities. Cognitive learning achievement in trial field was illustrated in Table 3. Table 3 indicated that both classes have achieved completeness. The results of student performance skills were presented in Table 4, where it explained that students still difficult to describe problem and formulate the hypothesis. Other than that, the results of psychomotor performance were drawn in Table 5 follows.

Table 1: The summary of expert opinion about learning device

	Expert opinion			
	Individual		Panel session	
Learning device components	Mean	Category	Mean	Category
Syllabus	3.8	Valid	4.0	Very valid
Lesson plans	3.8	Valid	3.9	Valid
Worksheets	2.9	Quite valid	3.8	Valid
Teaching materials	2.8	Quite valid	3.3	Valid
Device assessment sheets	2.8	Quite valid	3.8	Valid
Process assessment sheets	2.8	Quite valid	4.0	Very valid
Psychomotor assessment sheets	2.9	Quite valid	3.8	Valid
Critical thinking assessment sheets	2.9	Quite valid	3.8	Valid

Description: 4 = Very valid; 3 = Valid; 2 = Quite valid; 1 = Less valid

Table 2: The summary of lesson plans implementation in small class

Stages	Mean	Category
Initial activity	3.5	Mostly done
Main activity	3.5	Mostly done
Final activity	4.0	All done

Category: 4 = All done; 3 = Mostly done; 2 = Implemented partly; 1 = No accomplishment

Table 3: Learning outcomes on trial field (MCC by 75%)

	Pre test		Post test		
Σstudents	U	DNU	U	DNU	Percent
35 (A class)	0	35	29	6	82.86
33 (B class)	0	33	27	6	78.79

Description: U =Understand; DNU = Do Not Understand

Table 5 pointed out that students still find difficulties on 2 parameters, putting the plate, holding the glass measure and cutting the tube and restoring the scale, returning the glass and transferring the fruit flies into the bottle. Furthermore, the observation of spiritual attitudes was served in Table 6.

Table 6 showed that the spiritual attitudes (gratitude) of the students were already well. Besides that, Table 7 in this following section was represented the character observation of the students.

Table 7 tried to describe the character of the students in its behavior (discipline and responsible) in which this was also already good. Moreover, the results of social skills observation can be seen in this following Table 8. The social skills of the students (cooperation and ideas contribution) as illustrated in Table 8 were good.

Still, the results of critical thinking skills assessment can be found in Table 9. Table 9 proved that students still have difficulty in formulating a hypothesis, whereas the parameter of problem and conclusion formulation needs to be improved.

Table 4: Performance assessment

		Performance detailed score (N = 5)					
Class	Variables	1	2	3	4	5	6
X MIA4	Mean	9.4	6	18.8	20	24	12
	Category	Less good	Less good	Good	Very good	Very good	Quite good
X MIA3	Mean	8.4	8	18.6	20	22.4	14.4
	Category	Less good	Less good	Good	Very good	Very good	Quite good

Description: Very good (20-25), Good (15-<20), Quite good (10-<15), Bad (<5), Less good (5-<10). An adaptation of Purwanto: describing problems formulation; formulating the hypothesis; designing the experiment; conducting experiments to obtain information; gathering and analyzing data; making a conclusion

Table 5: Psychomotor assessment

Student's		Score				
name	Parameters	1	2	3	4	5
PF	Using scales	Less good	Good	Very good	Good	Less good
	Using glass measure	Less good	Very good	Quite good	Very good	Less good
	Using tube	Less good	Quite good	Very good	Good	Quite good
M	Using scales	Less good	Very good	Very good	Good	Less good
	Using glass measure	Less good	Very good	Good	Very good	Less good
	Using tube	Less good	Quite good	Very good	Very good	Less good

Description: Very good (24-30), Good (18≤24), Quite good (12≤18), Less good (6≤12), Bad (<6). An adaptation of Purwanto, Psychomotor RTK: using scales (1: putting the plate; 2: filling the plate with soil; 3: weighing the soil; 4: reading the scale; 5: restoring the scale); using glass measure (1: holding it; 2: pouring water into the glass; 3: measure the water volume; 4: pouring water into a bucket; 5: returning the glass); using tube (1: cutting the tube; 2: inserting a gauze; 3: combining two tubes; 4: sucking the fruit flies; 5: transferring the fruit flies)

Table 6: The mean of spiritual attitudes assessment (N = 5)

	Gratitudes of meeting day x					
Class	1	2	3	Σ score	Mean	Category
A class	3	4	4	11	3.7	Good
B class	4	4	4	12	4.0	Very good

Description: 4 = Very good; 3 = Good; 2 = Quite good; 1 = Less good

Table 7: The mean of students character (N = 5)

	Discipline of meeting day x						Responsibility of meeting day x					
Class	1	2	3	Σ score	Mean	Category	1	2	3	Σ score	Mean	Category
A class	3	4	4	11	3.7	Good	4	4	4	12	4	Very good
B class	4	4	4	12	4.0	Very good	4	4	4	12	4	Very good

Description: 4 = Very good; 3 = Good; 2 = Quite good; 1= Less good

Table 8: The mean of student's social skills (N = 5)

	Discipline of meeting day x						Responsibility of meeting day x					
Class	1	2	3	Σ score	Mean	Category	1	2	3	Σ score	Mean	Category
A class	4	4	4	12	4	Very good	3	3	3	9	3	Good
B class	4	4	4	12	4	Very good	4	4	4	12	4	Very good

Description: 4 = Very good; 3 = Good; 2 = Quite good; 1= Less good

Table 9: The mean of student critical thinking skills (N = 5)

		Parameter score					
Class	Variables	1	2	3	4	5	6
A class	Mean	12.8	5.6	19.2	21.8	19.2	10.8
	Category	Good	Less good	Good	Very good	Good	Quite good
B class	Mean	13.0	10.6	17.0	20.6	19.2	12.0
	Category	Quite good	Quite good	Good	Very good	Good	Quite good

Description: Very good (20-25); Good (15≤20); Quite good (10≤15); Less good (5≤10); Bad (<5)

Table 10: The mean of student's activity (N = 5)

		Observed components						
Class	Variables	1	2	3	4	5	6	7
A class	Mean	3.6	3.8	2.2	3	3	4	3
	Category	Good	Good	Quite good	Good	Good	Very good	Good
B class	Mean	2.4	3.2	2.6	3.2	3	3.8	3.8
	Category	Quite good	Good	Quite good	Good	Good	Good	Good

Description: 4 = Very good, 3 = Good, 2 = Quite good, 1 = Less good; 1: students pay attention to teacher's explanation; 2: students observe the presented problems (cases); 3: students ask questions; 4: students sit in groups; 5: students do the worksheets; 6: students conduct experiments; 7: students make conclusion

Table 11: The mean of teacher's activity in trial field

	A class		B class	
Paramerters	(score %)	Category	(score %)	Category
Pre-learning	100.0	Very good	100	Very good
Main activity	97.5	Very good	100	Very good
Closing	100.0	Very good	100	Very good

Description: Very good (86-100%); Good (76-85%); Quite good (60-75%); Less good (55-59%); Bad (≤54%)

After that student activity was written in Table 10 in which it explained that the student activity was already good except the questioning skills which certainly need to be improved. Likewise, the teacher's activity was presented in Table 11 and showed a good indicator.

So from here we can see the conclusion of this research such as: learning device is already valid, it is practical to be used in initial activity, main activity and final activity in which it performs well this is also effective to be used under the consideration of: study completeness, good student's performance (designing experiments, conducting experiments, gathering data and making a conclusion) even though the formulation of the problem and hypothesis skill needs to be improved, good psychomotor skills (using scales, using a measuring glass and using tube), good spiritual attitude (gratitude), good student character (discipline and responsible) and excellent social skills (cooperation and ideas contribution), good student activity while the questioning skills also need to be enhance. Good teacher activity in the learning management, good student critical thinking skills (designing experiments, conducting experiments and collecting data), however, students still have difficulties in formulating a hypothesis whereas the parameter of the problem formulation and conclusion formulation needs to be developed more.

DISCUSSION

Learning device validity: This development research has resulted in a valid, practical and effective learning device. Each indicator is a prerequisite thing for the next indicator (Tessmer, 1998). Moreover, Plomp and Nieveen reported that from 43 cases of development research, there are 14 reports that focus on theory of development and 3 reports focus on theory of validation.

Several studies have found valid learning device based on the opinion of 3 experts as well as students (Samidi, 2015; Setyowati, 2015; Kartini, 2015). This is in contrast to other research that merely based on the expert's opinion (Zaini and Asnida, 2015; Zaini and Safitri 2016). Both of that research above has assumed that student opinion is an expectation of practicality.

Expert opinion is carried out twice in this study. The first stage is that expert team works individually while the second stage is that they do the evaluation through panel session. In accordance to that, the result of this research showed a consistent validity in the learning device. However, this is in contrast with other studies where the expert team only do a validation once (Samidi, 2015; Setyowati, 2015; Kartini, 2015; Zaini and Asnida, 2015; Zaini and Safitri, 2016).

In this study, all learning device is declared to be valid. This result is then brought to be used in a small trial group in order to establish the practicality. This is called as a practical device if the user feels easy to use it in the learning process (Tessmer, 1998). In order to avoid a bias, to determine the practicality in the small trial group, teachers are also distributed to guide.

The results showed that teachers can implement the learning process in which this is in line with several studies that have been reported previously (Hidayati, 2015; Al Wardah, 2015; Yunita, 2015; Yana, 2015). Practicality is a requirement to carry out a trial field so that the effectiveness of the lesson plans can be realized. The trial field is the final stage of formative evaluation aimed to improve the learning device so that it could produce a prototype. Nevertheless, the implementation of the prototype has not been widely reported; based on 43 research reports there is only one study which could be labeled as an implementation study.

Learning device effectiveness: Effective learning device is used based on the parameters to achieve the ultimate goal in the formative evaluation (Tessmer, 1998). A learning process that is conducted with inquiry model in the trial field will produce a cognitive learning that is over minimum completeness criteria. However, the results of

this study do not distinguish cognitive product and cognitive process means that this was a weakness. Nonetheless, the results of this study are consistent with several previous studies (Jumirah, 2015; Hidayati, 2015; Al Wardah, 2015; Yunita, 2015; Yana, 2015; Ita, 2013). In the previous study, it is found that the learning completeness of cognitive product and the cognitive process is one of the effectiveness parameters for learning device. Schaal *et al*. (2012) concluded that the inquiry-based learning is great in the field of student's motivation and cognitive.

On the other hand, student performance (designing experiments, conducting experiments, gathering data and making a conclusion) is already good. The results of this study are supported by previous studies that found student performance in designing experiments, compiling an observation table and reviewing the data is classified as a good category (Rahmaniati, 2011). While unfortunately, the skills to make problem formulation and hypothesis need to be improved. This is in contrast with a previous study (Rahmaniati, 2011) in which the student performance in formulating a problem and its answer is temporarily well established. The observation of student performance in this study is carried out based on the parameters and reported separately. Whereas, this is in contrast to other studies which reported student performance in general and included in a good category (Jumirah, 2015; Yana, 2015). Thus, this research aims to develop student thinking skills because they learn the subject of the knowledge to be used and to be understood in the development of their competence in the field of investigation (Kong and So., 2008).

Besides that, psychomotor skill is also quite good. Several studies (Jumirah, 2015; Hidayati, 2015; Al Wardah, 2015; Yunita, 2015; Yana, 2015; Ita, 2013) are also in accordance with this statement. The difference only lays on the activities; students which were observed only consist of 4-5 people to make this observation effective. Lohner *et al*. (2005) expressed that inquiry teaching is effective to make students evaluate and build their own hypotheses as well as to obtain their own conclusions.

Meanwhile, it is not only the result of spiritual attitude assessment (gratitude) that is good but also the character of the students (discipline and responsible). Still, the social skill of the students (cooperation and ideas contribution) is in excellent condition. To support this idea, many types of research are in line with this result (Jumirah, 2015; Hidayati, 2015; Al Wardah, 2015; Yunita, 2015; Yana, 2015; Ita, 2013). The other parameters such as student activity and teacher activity are also good even though the questioning skills of the students need to be improved.

Critical thinking skill of the students (designing experiments, conducting experiments, collecting data) shows a good indicator but the students still have difficulty in formulating a hypothesis and the parameter of problem formulation and conclusion formulation needs to be improved. According to Bissell and Lemons (2006), the first two categories of Bloom taxonomy cannot measure student critical thinking skill. Proulx (2004) suggested several activities that included in critical thinking skill enhancement such as evaluating the arguments of the main ideas, the resources, the evidence and the recognition.

Inquiry-based learning is believed to raise the awareness of the students to process science. This learning model does not make changes to the conceptual knowledge of students if they already know the content of such knowledge (Ogan-Bekiroglu and Arslan, 2014). Cotter and Tally (2009) stated that textbook including its exercise within is already intended to improve student critical thinking skills but its effectiveness cannot replace the role of summative evaluation.

Foulds and Rowe (1996) explained that skill development is a significant process in which it can be achieved as part of the effects of short-term programs in science education, particularly in regard to the low ability of the students to design experiments. This is in accordance with the opinion of Lohner *et al*. (2005) that an important purpose of science education is to help students understand the real world in a scientific way and to offer an authentic view of scientific work which science misconception often occurs as a collection of facts.

This is different with student performance; student critical thinking skill is gained from the ability to do worksheets while student performance is acquired when students work on an observation and investigation. When students find difficulty in its performance skill, they will also experience such problem in their critical thinking skill. Therefore, teachers need to be more concrete on the pedagogy model and learning method so that the inquiry model can be applied effectively in order to guide students in a variety of pedagogical situations (Rahikainen, 2001). In this study, there are 3 important parameters such as formulating hypotheses, making the problem formulation and compiling conclusion. By that student's critical thinking skill needs to be trained so that scientific literacy can be realized well. Riggs (2014) assumed that there are linkages between development issues and critical thinking. One of the challenges is the awareness of thinking in life and its correlation with daily problems.

CONCLUSION

Learning device development results with twice the validation process showed a more appropriate and more

practical and easily used by the teachers. The device was also effective based on the observed parameters from small and big classes test that resulted in a good category such as: study completeness, student performance, psychomotor skills, spiritual attitudes, student character, social skills, critical thinking skills, student activity and the last is teacher activity.

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