Development of a Process Image-Based Physics Module to Improve the Students' Critical Skills in Technology and Engineering at Vocational Schools

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ABSTRACT

This study aims to create a valid and effective process image-based physics module for improve the students' critical thinking skills in SMK. This type of research is included in the development research. The development procedure adapts the 4D development procedures with the steps including: (a) define, (b) design, (c) development, and (d) dissemination. The assessment instrument was obtained from 4 validators to find out the validity of the physics module based on the image processing and data collection in the form of a written test to measure the effectiveness of the use of the learning modules at a classroom. The data analysis technique used the normalized gain (N-gain). The results showed that; (1) the process image-based physics module which was developed is a valid and feasible to use based on the assessment of expert validators and user validator with an average score of 4.23, (2) the process image-based physics module which was developed is effective enough with an the value of N-gain 0.62. So it can be concluded that the process image-based physics module is feasible and can be used in classroom to improve the critcal thinking of the students at vocational schools.

Keyword: *Process image-based physics module, Validity, Effectiveness, Critical thinking.*

1. Introduction

In the 21st century, education is increasingly important to ensure the students to have the skills to learn and innovate, to use the technology and information media, and to be able to work, and to survive by using the life skills (Fitriani, *et al.:* 2015). According to Sutarto and Indrawati (2010: 1), Physics is a field of study that discusses a lot about nature and its symptoms, from the real ones (visible in reality) to the abstract ones or even just in the form of theories whose discussion involves the ability of imagination or the involvement of a person's strong mental image. The problem in the field of Physics studies that often arises is the lack of students' ability to understand the material concept of Physics. It can be caused by students being less active in the learning process or because students begin to feel bored with the learning process that the learning outcomes are less than optimal. The role of a teacher is very important in helping to trigger the critical thinking skills of students with learning media, methods used, questions given to students, and assignments from the teacher that require students to solve them by means of critical thinking.

The module is one of the learning medias in the form of an independent textbook which includes a series of learning experiences that are arranged systematically aimed at helping students learn independently in a certain time unit so that students master the competencies taught (Wahyu, *et al* .: 2017). The module in the 2013 curriculum physics learning is used as a supplement to the learning resources of students in the learning process and with the use of the physics learning module is expected to be more active learning and can facilitate physics learning which is

classified as abstract or even only in the form of theory which the discussion involves the ability of imagination or involvement of a person's mental picture strong so that students have critical thinking skills.

The process image is a series of modeling images of objects, events or phenomena, which are relatively different between images, in terms of circumstances, position, form, or combination, which as a whole describes a stage that is coherent and is an integral whole (Sutarto, *et al* .: 2016). Angkowo and kosasih (2007) stated that image medias or graphic medias have several advantages. One of which is that it can attract students' interest in learning. Besides that, based on the results of the study (Rosadi, *et al*. 20:15), physics learning using discourse analysis tasks in the form of images of environmental events has several advantages, among others, students can develop their thinking power by digging and finding information themselves, active teaching and learning processes, students dare to express their opinions, critical, creative in analyzing and identifying a problem, students can apply the knowledge they have to solve a problem, students more easily understand the concept of physics, the student learning will be more meaningful so that the acquired knowledge is easier to remember.

Critical thinking skills are 21st century skills as ways of thinking which are very important to be developed in students. The concept of critical thinking is also part of Bloom's information processing taxonomy. The three highest levels in Bloom's taxonomy such as analysis, synthesis, and evaluation are often interpreted as critical thinking procedures (Bloom, 1956). According to Ennis (in Fatmawati, *et al*. 20-14), critical thinking is thinking in a reasoned and reflective manner by emphasizing decision making about what to believe or do. Indicators of critical thinking derived from critical activities according to Ennis (1996) are five, namely being able to formulate the main issues, reveal the facts needed to solve a problem, choose logical arguments, detect biases based on different points of view and determine the consequences from a statement taken as a decision. Critical thinking is needed by everyone to deal with problems in real life. Based on research (Retnowati, et al: 2016), basically, the stages of the critical thinking process include understanding the problem, analyzing the problem, identifying information which is relevant to the problem, planning solutions, drawing conclusions, evaluating the solutions that have been made, and looking for other alternatives in solving problems.

Based on the description above, the module can be used so that students are able to learn independently and can find their own knowledge. In addition, the process image is a medium used in an effort to clarify the understanding of students and can be used so that students have critical thinking skills. So the researchers are interested in conducting a research entitled " Development of a Process Image-Based Physics Module to Improve the Students' Critical Skills in Technology and Engineering at Vocational Schools

1.1 Statement of the problem

Based on the background above, the formulation of the problem that can be taken for this research is as follows:

a. how valid process-based image-based physics module for use in learning activities to improve critical thinking skills of SMK student?
b. How result the effectiveness of learning by using process-based physics picture modules for development critical thinking skill of SMK student?

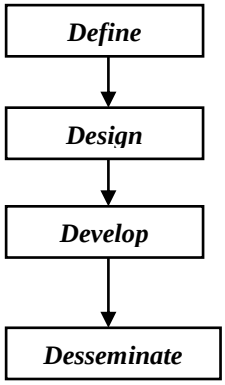
1.2 Objectives of the present study

The following are the objectives of the present study:

a. Describe the validity of the picture-based process physics module to develop critical thinking skills of vocational students.
b. Describe the effectiveness of learning result using process-based physics picture modules to development critical thinking skills of vocational students

2. Methodology

The research with the title of the development of an image-based Physics module process to improve critical thinking skills of vocational students is a development research that develops a module for physics learning whose interpretation is mostly expressed in the form of Process Images. The development model that is the reference of the researcher is the 4-D Model (Thiagarajan *et. al*., 1974: 9). This research is oriented towards the product development where the development process is examined as closely as possible and the product is finally evaluated. The product mentioned is a process-based image physics module with Define, Design, Develop, and Disseminate stages.



- Initial and end analysis (analyzing the needs of teachers and students)
- Defining the image-based process Physics Module
- Discussing the theory on the image-based porocess Physics module
- Designing the image-based process Physics module (***Prototype 1***)
- Expert Validity and User Validity
- Small Team Test
- Big Team Test →***Prototype* Final Module**
- The prototype of the image-based process Physics module is done and tested to other schools

Fig 1. 4-D Thiarajan Development Module

The technique of data collection used is the validity survey, observation and test. The pre test and post test data collection is to measure the effectiveness of the module use in class learning and is analyzed using *normalized gain (N-gain).* Observation is applied to know the conduct learning and the students' critical thinking skills. This observation was done at SMK 3 Pancasila Ambulu in class X TPM 1 on 30 July 2018 until 14 August 2018 in the first semester of the academic year 2018/2019. The consideration in choosing the place of development test is that: (1) The appointed school was willing to be the place of the development test; (2) The school appointed is the National-Standardized School (SSN) with the A accreditation; (3) The school appointed had never developed the image-based process module on Pysics subject on the materials of Temperature and Heat.

3. Result and Discussion

3.1 Needs and Context Analysis Result

The results of this preliminary stage are finding potential or problems before conducting research. In this step, the collection of supporting literature related to the module will be developed with interviews with 4 teachers in the field of physics study and questionnaire distribution to 20 vocational students.

Table 1. Results of analysis of teacher interviews

No.	Deskripsi	Persentase (%)
1	Do you think the pictures listed on the Physics textbook are interesting and can clarify the concept ?	25
2	Does the Physics textbook used in Vocational Schools have developed critical thinking skills ?	25
3	Is the Physics textbook used in Vocational Schools able to foster independent learning in learning Physics?	25
4	Do you require students to bring Physics teaching materials when learning Physics?	100
5	Have you used contextual teaching materials?	25

Based on Table 1, the results of the teacher's needs analysis on the condition of available textbooks in schools on average have not been able to attract students' attention in clarifying the concept, have not been able to foster critical thinking skills and independent learning. This can be strengthened by the results of interviews with teachers who obtained the percentage of each statement about Physics teaching materials less than 50%. So the need for Physics teaching materials, that can attract students' attention in clarifying the concept, can foster critical thinking skills and learning independent in accordance with 21st century learning.

Table 2. Results of questionnaire analysis of student needs

No.	Deskripsi	Persentase (%)
1	Do you like learning Physics?	20
2	Are you provided with a Physics textbook at your school?	100
3	Are Physics textbooks in schools interesting for you?	20
4	Do you like to read the available Physics learning teaching materials?	10
5	Are the pictures contained in Physics textbooks interesting and can clarify your physics concepts?	30

Based on Table 2. the results of the analysis of student needs about learning Physics on average do not like learning Physics because physics learning is difficult, is abstract and only relates to formulas. While the condition of textbooks available in schools on average has not been able to attract the attention of students to like learning Physics and the pictures available in textbooks are still difficult to study. This can be strengthened by the results of a questionnaire analysis with 20 students who obtained a percentage of each statement about Physics teaching materials that amounted to less than 50%. So there is a need for Physics teaching materials that can attract students' attention to learning Physics.

Based on the results of the analysis of teaching materials, it can be concluded that the teaching materials used so far in Pancasila 3 Vocational School still use the 2013 curriculum Bse package provided by the government. The textbook is not yet integrated with the drawing process and does not require students to study independently. Thus, based on observations of teacher needs and students' needs it can be concluded that the preparation and development of process-based physics picture modules for critical thinking skills needs to be carried out as soon as a product of learning strategies.

3.2 Design Results

The results of this development stage are in the form of new product designs. The image-based physics process module with "temperature and heat" material is a new product design developed. The following is a product design display in the form of a process image-based physics module.

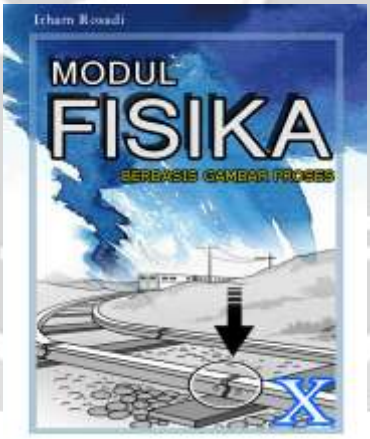


Fig 2. Front view module display

3.3 Development Result

This step is carried out to produce a product in the form of textbooks that fulfill the feasibility of content, language, presentation, and graphics. This stage includes consultation with experts so that the prototype 1 will produce a prototype 2. Validation of the product in question is validation related to the feasibility of the content, language, presentation, and product graphics using validation instruments. Validation was carried out by two Science Education Master's lecturers and two user validators, namely teachers from schools who were conducted as places and context analysis. The validator will then provide input and suggestions on textbooks developed for improvement. As for the valid prototype 2, it will proceed to the third step and this validation process to determine the feasibility of a module.

3.3.1 A valid process-based image physics module

The valid modules according to Nieeven (1999) are modules that are developed according to needs, product designs are based on the latest scientific knowledge, there is an element of renewal, consistency in graphics, and linguistics. The results of the Physics Validation Module based on the process of image can be seen in Table 3 (expert validator) and Table 4 (user validator).

Table 3. Results of Process-Based Physics Module Expert Validation Analysis

No.	Validator	Validator Score obtained by each validator		Average	Criteria
		Validator 1	Validator 2		
1.	Material	3,95	4,05	4,00	Valid
2.	Media	3,99	4,51	4,25	Valid
3.	Development	4,08	4,54	4,31	Valid
Average value				**4,18**	**Valid**

Based on Table 3, the results of the assessment analysis of two expert validators, obtained the value of the validity of the material from the process image-based physics module of 4.00 with a valid category. The results of the analysis of media validity were 4.25 with valid categories and the results of the analysis of the validity of the module development were 4.31 with valid categories. Based on the analytical data above, the average expert validation of the process image based module is 4.18 with a valid category, which means that the image-based physics module is valid and it can be continued in field trials.

Table 4. Results of Process-Based Physics Module User Validation Analysis

No.	Component Aspect	Score obtained by each validator		Average	Criteria
		User 1	User 2		
1.	Function and Benefits	4,00	4,75	4,37	Valid
2.	Feasibility of Presentation	4,21	4,64	4,42	Valid
3.	Feasibility to Integrate	4,00	4,41	4,20	Valid
4.	Linguistic Feasibility	3,92	4,46	4,19	Valid
	Average			**4,29**	**Valid**

In Table 4. it can be seen that the assessment of the user validator on the validity of the physics-based image module process obtains an average score of 4.29 then interpreted in a very valid category. Assessment of user validation instruments includes; function and benefits, presentation aspects, graphic components, and linguistic aspects. The conclusion is that the process-based physics picture process material is temperature and heat is valid and can be continued in field trials.

3.1.2 An effective image-based physics process module

Effective textbooks according to Nieeven (1999), namely textbooks that can achieve the learning outcomes or targets to be achieved. An effective image-based physics module in this study is known from the results of N-gain analysis. This study uses 3 learning activities where each learning activity is given an action treatment so that its reliability reaches the level of research. Data on the student learning outcomes in SMK 3 Pancasila in class X TPM 1 can be seen in table 5.

Table 5. Data on student learning outcomes in SMK 3 Pancasila

No.	Learning Activity	Average value of *pre-test*	Average value of *post-test*	*N-Gain*	Categori
1	1	33,35	69,32	0,55	Effective enough
2.	2	33,35	74,77	0,62	Effective enough
3.	3	33,35	75,55	0,62	Effective enough

Based on the results of the data analysis above, the effectiveness of physics learning in learning activities 3 for class X TPM 1 in 3 Pancasila Vocational School after learning by using a physics-based image module process in

learning activities 3 of 0.62 with the interpretation of the criteria for improving learning outcomes in the category quite effective. The learning activities 3 have experienced an increase in the value of learning outcomes and critical thinking skills compared to learning activities 2. This is due to the reflection of learning activities 2 so that learning outcomes 3 learning activities have increased. But this learning activity will be stopped because it has reached the desired target. The target is if the physics-based image module reaches the effectiveness criteria, namely the average post-test score of students ≥ 70.

4. CONCLUSIONS

Based on the data obtained in the results and the discussion, the conclusion drawn includes: (1). The results of expert and user validation tests on the development of image-based physics process material temperature and heat in physics learning for vocational students with the average value of expert validation by 2 validators of 4.18 interpreted in the criteria "valid ", While the value of user validation by 2 teachers of Physics subjects is 4.29 with" valid "criteria. Based on the results of the validation, the process-based image physics module is ready for learning activities; (2) The results of the effectiveness test on the development of picture-based physics and temperature-based physics modules in physics learning for vocational students have an increase in learning outcomes based on Normalized gain with an average of 0.62 with "quite effective" criteria, while the percentage of critical thinking skills (Performance Test) with an average of 68.46 in the "good enough" category. Based on the results of the effectiveness of the proficiency level, the image based process physics module is quite effective in learning physics.

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