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Development of Inquiry-Based Mechanics Teaching Materials to Train Critical Thinking Skills for FKIP Physics Students, Universitas Pattimura Ambon

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Abstract:

This research is to produce inquiry-based mechanics teaching materials to train critical thinking skills of Physics FKIP students, Pattimura University, Ambon. The research design used the Kemp model (1994) and the learning process was packaged in an inquiry setting with a total sample size of 26 students in the 2020/2021 school year. The data collected were in the form of teaching material validation data, critical thinking skills test instrument validation data, critical thinking skills data, and student response data. The data analysis techniques used include: qualitative descriptive analysis including: the results of validation of teaching materials, the results of instrument validation tests of critical thinking skills, the results of critical thinking skills, and the results of student responses. The results showed that: 1) the validity of the student teaching materials developed was categorized as valid; 2) the validity of the developed critical thinking skills test instrument was categorized as valid; 3) in the percentage of critical thinking skills there is an increase in value from pretest to posttest by more than 40%; 4) Student responses to teaching materials and the implementation of learning are very positive and the lowest percentage is obtained, namely 85% satisfaction with a very good assessment. Based on the results, it can be concluded that the development of inquiry-based mechanics teaching materials can train critical thinking skills of Physics FKIP students, Pattimura University, Ambon.

Keywords:
critical thinking skills; inquiry models; development

I. Introduction

21st century human resources (HR) must have the competence to be able to work together, think critically, be creative, innovative, have the ability to communicate, and be able to solve problems (Framework for 21st century learning). Related to these competencies, educators have roles and responsibilities to strive for quality learning in terms of processes and results. Efforts to develop science learning related to improving the quality of processes and results, especially physics, must continue to be carried out. One of the efforts on how to teach physics to be effective and efficient, many researchers poured with various learning methods and learning media. This is done in an effort to make the physics paradigm difficult, it can be lost in the minds of students.

Critical thinking is an attempt to use skills and strategies that can solve a problem logically (Fazriyah, et al, 2018). Therefore, it is necessary for students to develop critical thinking skills in themselves. To develop students' critical thinking skills, educators need to create experience-based activities that create active student involvement in learning (Sulaiman,

2013). Experience-based activities involve the five senses so that through observation students can more easily learn an abstract concept (Sholihah, et al, 2016).

Based on observations at FKIP Physics, Patimura University Ambon, the learning carried out, especially mechanics, is still lacking in using teaching materials that can train critical thinking skills. Good teaching materials are teaching materials that are able to make students think at a higher level, one of which is critical thinking.

Critical thinking skills are also supported by previous research. According to Widdy (2018), the low achievement of Indonesian science is influenced by students' critical thinking skills towards a problem they face. Science learning is intended to provide meaningful experiences to children and also train critical thinking skills, because in science learning children understand various concepts (Rafida, 2020). Though critical thinking is needed by students to face various challenges. Critical thinking is a process that can be taught to students, but with a note that educators must be able to choose and determine the right learning model with the development of the students themselves. So that the right model to train students' critical thinking skills is the inquiry model.

According to Bruner (Sanjaya, 2006), inquiry learning allows students to be active in seeking knowledge so that it will increase the meaning of what they learn. This is in accordance with what was conveyed by Massialas, who argues that the inquiry model is a teaching model that allows students to move step by step from identifying problems, defining hypotheses, formulating problems, collecting data, verifying results, and generalizing conclusions, so that the inquiry model is very possible. students are actively involved, because students do most of the work that must be done (Nurfarida, et al, 2016: 11). Students use their thinking skills to learn ideas, solve problems, and apply what they learn.

Appropriate teaching materials need to be prepared by educators because of weak thinking skills and understanding of mechanics concepts not only depending on the inability of students to receive lessons, but also influenced by the ability of educators to manage learning activities and teaching materials used (Taufiq, 2014). The involvement of students in scientific inquiry is an important component of science instruction that helps students develop scientific literacy and provides them with opportunities to practice important critical thinking skills in addition to critical thinking and problem-solving skills (Khishfe and Abd-El-Khalick, 2002), so that learning is more meaningful.

In this study, researchers chose mechanical materials. Mechanics is a very fundamental branch of physics. Singh & Schunn (2009) stated that learning mechanics is often the main target of intervention in educational programs because concepts in mechanics are the basis for other branches of science and are closely related to everyday experience. Students' understanding of motion material in mechanics is still low, and misconceptions often occur. So, this needs to be researched.

Thus, the title of the research is "Development of Inquiry-Based Mechanics Teaching Materials to Train Critical Thinking Skills for FKIP Physics Students, Pattimura University, Ambon".

II. Research Methods

The development of inquiry-based teaching materials in this study adapts Kemp's (1994) model. In general, Kemp's teaching materials development model is shown in Figure 1.

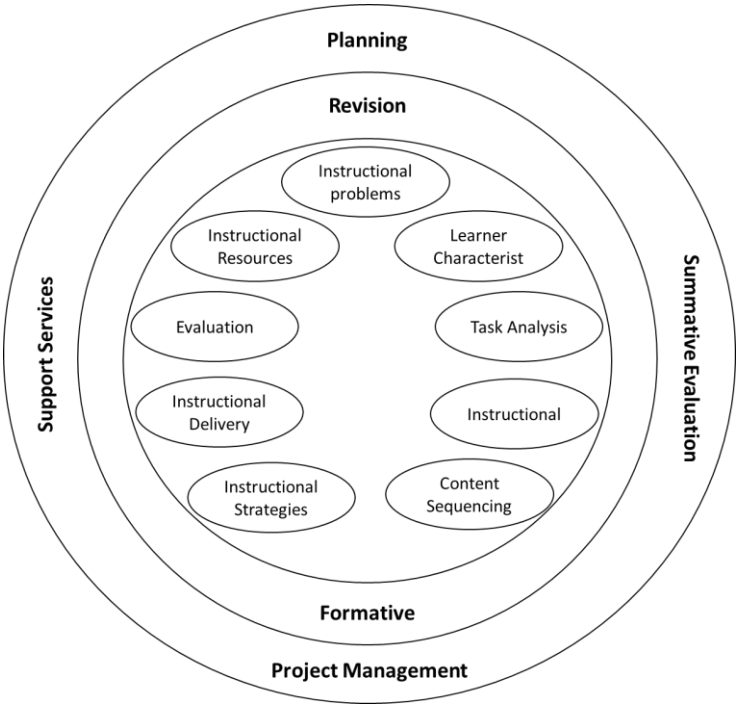

Figure 1. *The Development Cycle of the Kemp Model Device (Kemp, et al, 1994)*

The development of learning tools in this study adopted the nine elements of the Kemp, et al. model, 1994. The whole procedure in this study is divided into five stages, namely:

a. The first stage is device validation which aims to obtain advice from competent experts for the development of teaching materials and test questions;
b. The second stage is to test the device that has been developed with a limited number of students;
c. The third stage is to make revision I based on small-scale trials;
d. The fourth stage is testing the tools that have been developed in the research class;
e. The fifth stage is revision II and making a research report.

Data Analysis Technique

a. Learning Tool Validity Analysis

Data analysis of the validity of the learning device components was carried out by averaging the scores of each component. Emmer & Millett formula as follows:

$$Percentage\ of\ Agreement = 1 - \frac{A-B}{A+B} \times 100$$

…….. (1)

Information: A: Validation frequency observed with high frequency; and B: The observed validation frequency is low. The instrument developed is said to be reliable if the value of the percentage of agreement (Borich, 2015).$\geq 75\%$

b. Skill Analysis

The results of the assessment of students' critical thinking skills were obtained using the test method. Individual completeness is based on the specified standard of completeness. The value of students' aspects of critical thinking skills is stated on a scale of 0-100.

Table 1. Abstract Skill Aspect Predicate

Score	Criteria
86-100	Very good (A)
71-85	Good (B)
56-70	Enough (C)
≤ 55	Less (D)

c. Response Analysis

Determining the category of responses given by students to a criterion by matching the percentage results with positive criteria according to Khabibag (in Yamasari, 2010), namely:

Table 2. Response Criteria

Percentage (%)	Criteria
85% RS	Very positive
70% RS < 85%	Positive
50% RS < 70%	Less positive
RS < 50%	Not positive

III. Discussion

3.1 Validity Student Teaching Materials (BAM)

The results of the BAM validation assessment can be seen in Table 3.

Table 3. The Results of the Validation of Student Teaching Materials

No	Rated aspect	Average score		Average	Reliability	Category
		V1	V2			
1	Contents	3.50	3.50	3.50	100%	Valid
2	Material Presentation	3.38	3.75	3.56	94.74%	Valid
3	language	3.60	3.80	3.70	97.30%	Very Valid
4	Graphics	3.50	3.50	3.50	100%	Valid
Average		**3.50**	**3.64**	**3.57**	**98%**	**Valid**
Conclusion: Inquiry-Based Physics Student Teaching Materials (BAM) developed are valid for use by lecturers in the learning process.						

Description: V1: validator 1; V2: validator 2

Ingredients Teaching is one of the important factors in the effectiveness of learning, especially at the Higher Education level (Meilan, 2018). The lack of teaching materials can certainly affect the quality of learning or lectures. In the Guide to Writing Textbooks (Depdiknas 2005:3) it is stated that "what includes the content of education is everything that educators directly give to students and are expected to be mastered by students in order to achieve a certain competence in education." The teaching materials given to students must be of high quality. Quality teaching materials can produce quality students, because students

consume quality teaching materials. The criteria for assessing teaching materials in the form of handouts have at least four conditions fulfilled if a teaching material is said to be good, namely "(1) the scope of the material or content is in accordance with the curriculum; (2) the presentation of the material meets the principles of learning; (3) good language and legibility; and (4) the format of the book or interesting graphics" (Puskurbuk, 2012). In this study, the development of teaching materials (handouts) is inseparable from the inquiry model and critical thinking skills. So that in this teaching material deeper into the scientific method and critical thinking skills that will be trained by educators to students.

The validity of this study emphasizes 4 things, namely aspects of content feasibility, material presentation feasibility, linguistic feasibility, and graphic feasibility. The aspect of the feasibility of the content seen is the source of the material, the scope of the material, the introductory material, the type of material, the characteristics of the material, and the content of the material. This aspect gets an average value from two experts of 3.50 with a reliability level of 100% with a valid category. Aspects of the feasibility of presenting the material seen are systematic presentation, presentation of instructions for use, presentation of illustrations, presentation of material, presentation of examples, presentation of evaluations, presentation of terms, and presentation of bibliography. This aspect gets an average value from two experts of 3.56 with a reliability level of 94.74% with a valid category. The aspect of linguistic feasibility that is seen is that the material is presented by paying attention to the rules of sentence structure, the material is presented using effective sentences, the language used is communicative, the terms used are easy to understand, and the material is presented in accordance with good and correct Indonesian language rules (according to EBI). This aspect gets an average value from two experts of 3.70 with a reliability level of 97.30% with a very valid category.

Based on these data, it can be concluded that all the average aspects assessed in the validation of teaching materials are categorized as valid with an average score of 3.57 and a reliability of 98%. So, it can be said that the teaching materials (handouts) are appropriate to be used for research in the learning process to practice critical thinking skills in inquiry settings. It is hoped that these teaching materials (handouts) are expected to motivate students to read, do their assignments and arouse the curiosity of participants to carry out further exploration of the topics they are learning and can train students' critical thinking skills.

3.2 Validity of Critical Thinking Skills Test Instrument

The results of the evaluation of the critical thinking skills test instrument validation can be seen in Table 4.

Table 4. Critical Thinking Skills Test Validation Results

No	Rated aspect	Average			Reliability	Category
		V1	V2			
1	Contents	3.50	3.00	3.25	92%	V
2	Language	4.00	3.70	3.85	96%	SV
Average		**3.75**	**3.35**	**3.55**	**94%**	**V**
Conclusion: Critical Thinking Skills Test Instrument valid to be used by lecturers to measure critical thinking skills in physics learning by using an inquiry model.						

Description: V1: validator 1; V2: validator 2

Instruments are defined as tools that are selected and used in learning activities to collect so that the learning activities become systematic. Based on this definition, an instrument serves to capture learning outcomes. According to Ulfa (2016), the instrument is

also defined as a tool, a suggestion that can be realized in objects, for example a questionnaire (questionnaire), a list of matches (check list), interview guidelines (interview guide or interview schedule), test questions (test), inventory (inventory), and scale (scale). The instrument that was validated by the expert was the critical thinking skill test instrument. In this test instrument, the experts looked at two things, namely from the content aspect and the language aspect.

Aspects of the content seen are the suitability of the material with the test questions given, the suitability of indicators of critical thinking skills, and the level of difficulty of the test questions. This aspect gets an average value from two experts of 3.25 with a reliability level of 92% with a valid category. The language aspect that is seen is the language used is communicative, in accordance with the rules of good and correct Indonesian, and the sentences used are effective. This aspect gets an average value from two experts of 3.85 with a reliability level of 96% with a very valid category. The average result of the critical thinking skills test instrument by two experts is 3.55 with a reliability of 94% valid category.

Based on these data, it can be concluded that the critical thinking skills test instrument can be used before and/or after the learning process to measure students' knowledge of critical thinking skills indicators.

3.3. Critical Thinking Skills

Data on the results of critical thinking skills were obtained through a critical thinking skills test with a total of 12 questions, where each indicator of critical thinking skills contained 4 questions. Critical thinking skills assessed are:(1) the ability to formulate questions; (2) the ability to plan problem-solving strategies; and (3) the ability to evaluate decisions. The average results of critical thinking skills in 26 students of the Physics Education Study Program are generally shown in Figure 2.

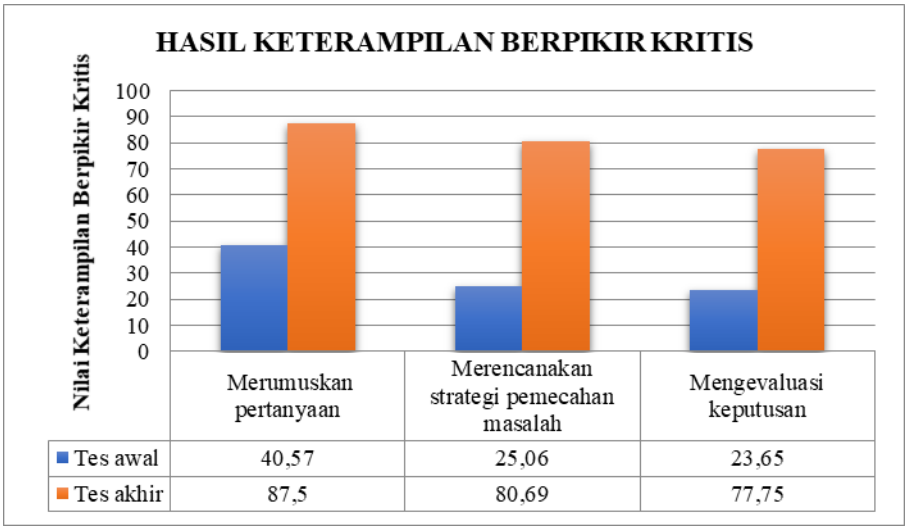

Figure 2. *Results of Critical Thinking Skills*

Critical thinking skills are skills that are not inherent in humans since birth (Rahmawati Ika, et al, 2016). *Critical thinking skills* becomes very necessary because Critical Thinking Skill itself is not limited to ordinary thinking processes (Ghiffar, 2018). According to (Christina, et al, 2017) Critical thinking is a person's ability to find information and solve a problem from a problem by asking himself to dig up information about the problem at hand. IThe indicators of critical thinking that are trained are (1) the ability to formulate questions; (2) the ability to plan problem-solving strategies; and (3) the ability to evaluate decisions.

The indicator of the ability to formulate questions cannot be separated from question words in the form of what, where, how, when, why etc. In formulating questions, students must know 2 things, namely (1) questions must have question marks; and (2) in the question contains two or more variables. This indicator gets an average pretest value of 40.57 and a posttest value of 87.5, so that the indicator of the ability to formulate questions gets an increase of 46.93. Ability indicatorplanning a problem-solving strategy in this case students are able to understand, apply and be able to analyze it. Problem solving requires a good level of analysis to be able to solve a problem. This indicator gets the valuethe pretest is 25.06 and the posttest value is 80.69, so for the ability indicator planning problem solving strategiesgot an increase of 55.63. Indicatorthe ability to evaluate decisions is an indicator that also requires a good level of analysis. In evaluating decisions, students already know the strengths and weaknesses of the decisions to be evaluated. This indicator gets the valuethe pretest is 23.65 and the posttest value is 77.75, so for the ability indicator evaluate decisions got an increase of 54.10.

Based on these results, the lowest increase in value from pretest to posttest is an indicator of the ability to formulate questions. This indicator is indeed quite difficult for students to understand, because this indicator requires a deeper understanding of what a variable and various variables are. The indicator with the highest increase is the ability indicator planning problem solving strategies got an increase of 55.63, because on this indicator students can connect understanding of the material being taught with the subject matter so that it is felt easier to understand.

What can be taken from this result is that learning by using the inquiry model can train students' critical thinking skills. This can be seen in the increase in scores from pretest to posttest by more than 40%.

3.4 Student Response

The results of student responses to teaching materials developed to practice critical thinking skills using an inquiry model were obtained from questionnaires distributed to students. There are 5 things that can be seen in student responses related to learning that is packaged using an inquiry model. The average results are shown in Figure 3.

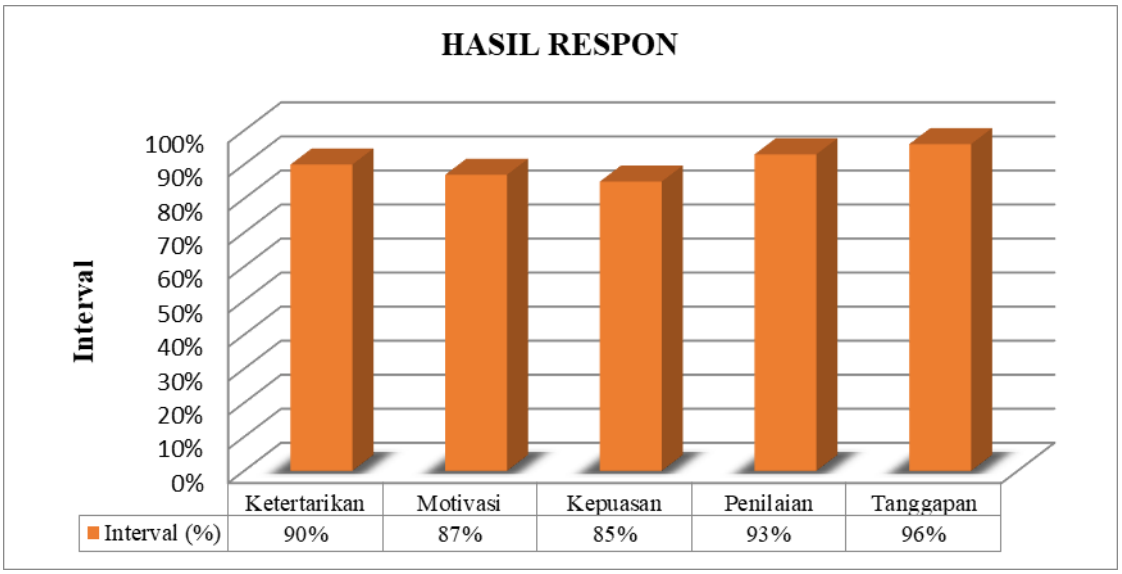

Figure 3. *Student Response Results*

Student responses use a questionnaire instrument that is given after the teaching and learning process by using an inquiry model to practice critical thinking skills. According to Hadari Nawawi (2007), a questionnaire is an attempt to collect information by submitting a number of written questions, to be answered in writing by the respondent. There are 5 things that can be seen in student responses related to learning that is packaged using an inquiry model. The five things are (1) interest; (2) motivation; (3) satisfaction; (4) assessment; and (5) responses.

The percentage of interest indicators is 90% with very good and very positive categories. This shows that packaged learning makes students interested in learning it. As in Maidiyah and Fonda's research which revealed that students' attention can be obtained by the way teachers are able to package learning so that it is not convoluted and easy to understand (Maidiyab, et al, 2013).

In the motivation indicator the percentage is 87% with very good and very positive categories. This shows that the teaching materials used, the teacher's teaching methods, and other facilities are able to make students motivated in learning. The motivation of students will appear in the completion of the tasks given by the teacher, besides that students in their activities are quite enthusiastic. Dimyati, et al, 2009 said that motivation is seen as a mental impulse that moves and directs human behavior, including learning behavior.

The percentage of satisfaction indicators is 85% with very good and very positive categories. This shows that the delivery of physics material using an inquiry model to practice critical thinking skills can make students want to know more about the material and critical thinking skills that are delivered and trained, in addition, students feel happy to learn physics material using an inquiry model. Wahyuningsih (2011) suggests that the increase in student learning is influenced by the existence of a fun learning activity process supported by increased interest and student activity in participating in learning activities.

In the assessment indicators and responses, the percentages are 93% and 96%, respectively, with both very good and very positive categories. This shows that the teaching materials developed in the inquiry package are able to make students get good grades. Students can also practice critical thinking skills by using inquiry-based teaching materials.

Based on this data, it can be seen that the indicator that has the lowest percentage is the satisfaction indicator, the percentage is 85%, because current conditions do not allow students to conduct experiments in the laboratory, but students use tools and materials that are easy to obtain in their daily lives.

IV. Conclusions

Based on the results and discussion, it can be concluded that the development of inquiry-based mechanics teaching materials can train critical thinking skills for FKIP Physics students, Pattimura University, Ambon.

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