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Development of meaningful investigation laboratory (mil) learning model to improve critical thinking skills in physics earning

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Development of meaningful investigation laboratory (mil) learning model to improve critical thinking skills in physics earning

S Astutik[1]*, I K Mahardika[1], Supeno[1], Indrawati[1], Sudarti[1] and A F Zakaria[1]
[1] Jember University, Kalimantan street no.37, Jember, Indonesia.

* tika.fkip@unej.ac.id

Abstract. Learning models must be innovative in 21st century. One important component in the 21st century is critical thinking skills. Learning models require innovation, not only in the classroom. The Meaningful Investigation Laboratory (MIL) learning model is the solution for the based laboratory learning model that can improve the ability of critical thinking skills. The research method is research and development Nieveen's Design. The results validation of MIL learning models and validation learning instruments is 92,5% and categorized as valid. There is an increase critical thinking skills after using the MIL learning model. This result is post-test higher than pretest with an N-gain value is 0.76 and categorized as high criteria. Students responses use MIL learning model is 84,52% positive responses and categorized very good. The critical thinking skills in the MIL learning model is found in every learning syntax. Critical thinking skills can be developed from: 1) Critical questions in precondition syntax, 2) Scientific experiment with critical thinking student workshhet in investigation syntax, 3) Reporting the results of investigations in critical class discussions in report syntax, 4) Reinforcement quiz are critical questions and analytical problems in the reinforcement syntax, and 5) Critical reflection from teacher to students and make conclusions together in reflection syntax.

1. Introduction

The demand for learning innovation in the 21st century is growing as a result of advances in science and technology. In this century, the change of philosophy of learning from the paradigm of transition to student-centered class activities [1]. Physics learning tends to be done in classroom rather than outside the classroom. Students will feel bored when monotonous learning is done in class. Physics learning can be done based laboratory so that it is not only monotonous in the classroom. Learning integrated with a laboratory increase student collaboration [2] This condition will trigger the students to study, work and take responsibility seriously to achieve the goals [3]. So the integrated learning with a laboratory can increase collaboration and effective for scientific experiment. Therefore, it is necessary to renew the learning model in the laboratory.

The learning model leads to a specific learning approach, including its objectives, steps (syntax), environment and management system [2]. The learning model has elements of syntax, social systems, reaction principles, support systems, instructional impacts and indirectly impacts [4]. The learning model is used by teachers during the learning process to create a pleasant learning atmosphere and motivate the students [5] So, the learning model is a systematic framework to achieve the learning objectives and motivate the students in learning.

The renewal of the learning model can be developed by combining several learning models. The Problem Based Learning (PBL) model has several stages such as orienting students, organizing students, guiding individual and group investigations, developing and presenting results, analyzing and evaluating the results in problem analysis [2]. The PBL learning model syntax does not include exercises or reinforcement in the questions form. To cover the weaknesses of the PBL learning model, it can be integrated with the Student Team Achievement Division (STAD) learning model. Quiz on the STAD learning model can motivate the students to be active in learning process and strengthen the understanding [6]. So, the advantages and disadvantages of PBL and STAD learning models can be combined into a new learning model.

Physics learning really needs something interesting that attracts students to the material learning before entering into the main substance . This is important because the character of physics material is

difficult to learn, so that the initial precondition is needed to minimize student bored. Students' interest can be built by giving phenomenon related to daily facts around students. The facts presentation related to daily phenomenon will be meaningful to students [7]. Physics learning should involve the experimental activities to synchronize and prove the concepts. The nature of physics learning in the form of processes and products can be developed by studying natural phenomenon [8]. Studying natural phenomenon in learning physics can be developed with experimental activities. One important substance in learning is the emergence of the substance of student retention. Retention is the ability to memorize the knowledge which is one of the important aspects in learning and can be improved by doing exercises [9].

The most important 21st century learning skills for students is critical thinking skills [10]. Critical thinking is a way of assessing statements' and reasonable reflective thinking focused on deciding what to believe or do [11]. According to Muhfahroyin [12], critical thinking is a process that involves mental operations such as induction deduction, classification, evaluation, and reasoning. So critical thinking is a mental process for analyzing or evaluating information. Critical thinking skills in Java in the last three years are still relative low, supported by research from several city in Indonesia. The results of the analysis of critical thinking skills in physics from 11 senior high schools in the Special Region of Yogyakarta found 2 schools in the low category, 7 schools in the low category, and 2 schools in the high category [13]. Whereas from the three senior high schools in Magetan Regency, the results of critical thinking skills of students amounted to 52.28% included in less category and 63.94% included in enough category [14]. And from two senior high schools in Malang with 115 respondents chosen random, 86.6% of students were included in the category of low critical thinking skills [15]. Of the two senior high schools in Bandung City, only 28% of the total students are able to indicator of critical thinking skills [16].

2. Methods

This type of research is a development research. Development research is research that produces certain products, and the effectiveness of these products. The products produced in this research development is learning model. This development research uses Nieveen *et al* [13] development research model consists of (1) Preliminary research, (2) Prototyping stage, and (3) Assessment stage (summative evaluation). The development of this learning model is a preliminary study that will later be trialled on a small and large scale and continued with the dissemination stage. The research design is depicted in Figure 1.

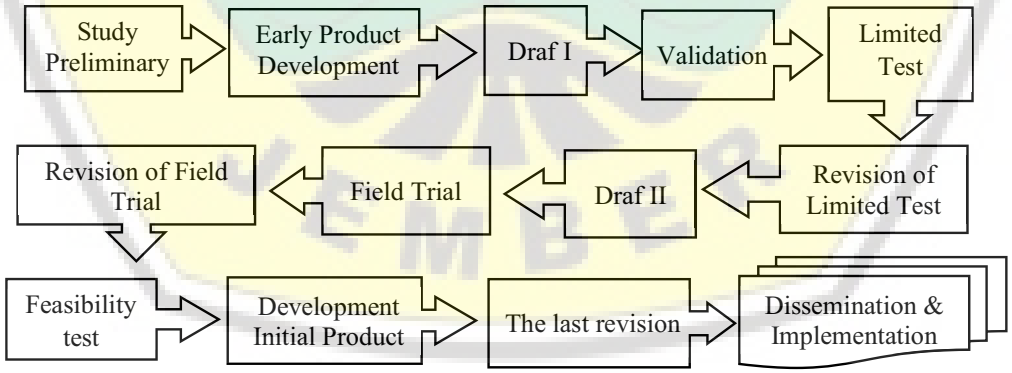


Figure 1. Design of Nieveen research development model.

Data collection techniques in this study is a test. The learning material used in this study is fluid. The data analysis technique used is qualitative quantitative descriptive analysis. Quantitative descriptive analysis is used to manage the results of the preliminary trial model development that will be done. While qualitative descriptive analysis is used to define quantitative data and categorize into certain classifications.

Before testing the MIL learning model and learning instruments must be validated lecturers from Jember University. Aspects raised in the validation instrument include supporting theory, model structure and desired learning outcomes. Expert validation with expert validation indicators is then presented with the formula:

$$Percentage\ value = \frac{\sum n}{\sum N} \times 100\%$$

Explanation :
n : number of values obtained
N : maximum number of values

After getting the percentage value then the validity level is categorized according to table 1

.**Tabel 1.** Validity category

Percentage	Validity Category	Explanation
80% - 100%	Very Valid	Very good to use
61% - 80%	Valid	May be used with minor revisions
41% - 60%	Valid enough	Good to use
21% - 41%	Deficient Valid	May be used with major revisions
0 – 20%	Invalid	Cannot be used

(Akbar, 2013:78)

After the MIL learning model and MIL learning materials included the valid category, a limited trial can be carried out on the developed model. The analysis of critical thinking used refers to the analysis of the level of critical thinking. The critical thinking indicator used refers to the critical thinking indicator developed by Ennis. The critical thinking indicator aspects developed by Ennis (2011) include: 1) Elementary clarification; 2) The basic for decision; 3) Inference; 4) Advanced clarification; 5) Strategies and tactics. The results of students' critical thinking skills aim to determine the effectiveness of the MIL learning model that has been given. The average pretest and post test results aim to find the formulated N-gain value :

$$g = \frac{S_f - S_i}{S_{max} - S_i}$$

Explanation :
g = gain
S_f = Post-test average value
S_i = Pre-test average value
S_{max} = The highest score obtained by students

According to Hake (1998), are divided into three categories which are explained in table 2.

Table 2. Levels of students' critical thinking

Coefficient	Criteria
0,70 ≤ normalized gain	High
0,30 ≤ normalized gain < 0,70	medium
normalized gain < 0,3	Low

Hake (1998)

In addition to student responses needed to know the practicality of the MIL learning model. Students responses in MIL learning can be formulated as follows:

$$\%Rs = \frac{A}{N} \times 100\%$$

Explanation :
Rs : Percentage of students responses
A : Proportion of students who choose yes or no
N : Number of students who filled out the questionnaire

Furthermore, percentage of students responses categorized by the criteria in table 3.

Table 3. Students Response Criteria

Percentage of Student Responses	Student Response Criteria
0 - 20	Not good
21 – 40	Less good
41 – 60	Enough
61 - 80	Well
81 - 100	Very good

[17]

3. Results and Discussion

3.1. Meaningful Investigation Laboratory (MIL) *Learning model*

This research is a research development that produces a product in the form of a new learning model, namely the MIL learning model with reference to the research model development of Nieveen . The stages of learning activities in the MIL learning model are a combination of the strengths and weaknesses of the Problem Based Learning (PBL) learning model and the Student Team Achievement Division (STAD) learning model. MIL learning model is illustrated in figure 2.

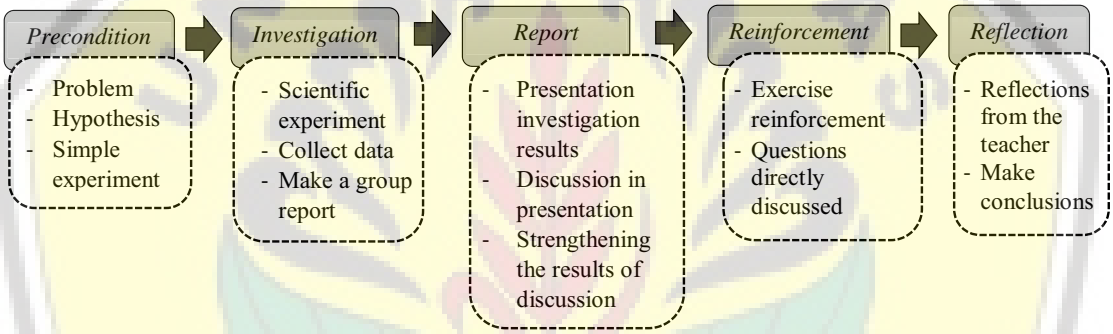


Figure 2. Concept map of MIL learning model

The syntax of the MIL learning model is :

Table 4. Syntax of the MIL model

MIL learning model phase	MIL learning model activities
Precondition	a) Students are given problems regarding physical contextual phenomena so that goals are clear and meaningful; b) Students are given questions related to problems that have been seen together. c) Students are guided to hypothesize related questions related to contextual phenomena around students given by the teacher. d) Students do the simple experiments as related material to increase interest in the material.
Investigation	e) Students collaborate and conduct experiments to answer hypotheses that have been made; f) Students experiment according to the student worksheet and collect data collaboratively; g) After taking data, students analyze the data obtained which will later be reported in the group reports
Report	h) Students make group reports. i) Each group comes to the front of the class to present the results of investigation; j) Other groups who do not come to the front of the class can respond or ask the group that present in front of the class.

	k)	Students get reinforcement from the teacher on the results of class discussions that have been presented by each group. If there are still incorrect answers the teacher can correct the hypothesis answer.
Reinforcement	l)	Students get reinforcement from critical quiz.
	m)	Questions directly discussed at that time.
Reflection	n)	Students get a reflection of learning that they have done.
	o)	Students and teachers make conclusions at the end of learning.

3.2. Meaningful Investigation Laboratory (MIL) Learning Model System

The learning system of the MIL learning model is as follows:

a. Social system

The social system in the MIL learning model is there is interaction between students when discussing in the investigation phase and there is interaction between groups at the report stage. Interaction between students in the MIL learning model will increase student participation and activity. In addition there are interactions between students and teachers through feedback given by the teacher to students. The teacher provides opportunities for students to construct knowledge and actively participate in the learning process.

b. The principle of reaction

In the MIL learning model, the teacher acts as a facilitator and responds to each student's opinion or answer at the precondition stage and group answers at the report stage. The teacher also acts as a facilitator in group investigations so students can construct their own knowledge so that learning becomes meaningful. In the view of learning theory, constructivism shapes knowledge, makes meaning, is critical, and forms justification so learning is a form of independent learning. In the MIL learning model provides interaction between all students, interaction between groups, interaction between students and teachers, and interaction between groups and teachers.

c. Support system

The support system needed in the MIL learning model is all the learning resources needed in the learning activities as for example experimental kits, student worksheets, etc.

d. Instructional Impact

The instructional impact in the MIL learning model is the critical thinking skills of 21st century learning.

e. Indirect impact

Indirect impact of MIL learning models are: 1) Careful in processing data; 2) Careful when experimenting; 3) Careful in group investigations; 4) Increase student collaboration; 5) Respect the opinions of others; 6) Dare to express his opinion during the presentation.

3.3. Validation MIL Learning Model and Learning Instruments

Validation of the Meaningful Investigation Laboratory (MIL) learning model is validated to reduce errors in the data collection process. The validation results of MIL learning model and learning instruments are presented in table 5.

Table 5. Validation results of model and learning instruments validation

No	Validation	Validation Results	
		Average Percentage	Criteria
1.	MIL learning model	91,67%	Valid
2.	Learning instruments	93,33%	Valid
	Average of validation	92,5%	Valid

The results of the validation of the MIL learning model by the lecturers showed a validation the average percentage is 91,67%, based on the validation criteria is valid. And the results of the validation of the instruments learning model by the lecturers showed a validation the average percentage is 93,33%, based on the validation criteria is valid. Average of validation is 92,5%, based on the validation criteria is valid. Based on the results of the validation of the MIL learning model and

instruments learning instruments categorized as valid and can be used in physics learning in senior high school.

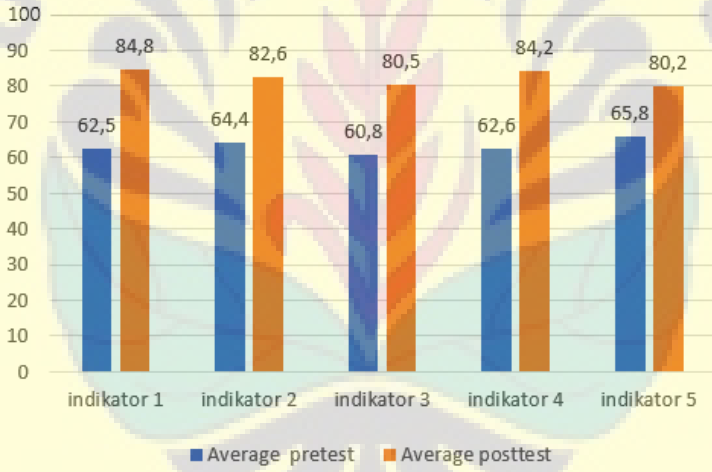
3.4. Critical Thinking Skills in the Meaningful Investigation Laboratory (MIL) Learning Model

The ability critical thingking skills has increased using the MIL learning model on fluid physic material. The N-gain value of students 'critical thinking skills using the MIL learning model is shown in table 6. While the graph of students' critical thinking skills using the MIL learning model is shown in graph 1.

Table 6. N-gain values of students' critical thinking skills using MIL learning models

Indicators of Critical Thinking	Average Pretest	Average Posttest	N Gain	Criteria
Elementary clarification	62,5	84,8	0,76	high
The basic for decision	64,4	82,6	0,77	high
Inference	60,8	80,5	0,78	high
Advance clarification	62,8	84,2	0,79	high
Strategies and tactics	65,8	80,2	0,71	high
Average	63,22	82,46	0,76	high

Graph 1. Graphic critical thinking skills of students using the MIL learning model



Based on the N-gain of students' critical thinking skills using the MIL learning model on the elementary clarification indicator is 0.76, basic for decision indicator is 0.77, inference indicator is 0.78, advanced clarification indicator is 0.79, and strategies and tactics indicator is 0.76. The mean N-gain of all indicators of students' critical thinking skills using MIL learning models is 0.76. Criteria for N-gain critical thinking ability of students using MIL learning models on elementary clarification indikator is categorized as high, basic for decision indicator is categorized as high, inference indicator is categorized as high, advanced clarification indicator is categorized as high, and strategies and tactics indicator is categorized as high. The mean N-gain of all indicators of students' critical thinking skills using MIL learning model is categorized high.

After using the MIL learning model there was an increase due to innovation from monotonous learning in the classroom to the laboratory based renewable learning. It also supported by the characteristics of learning physics that must be integrated with the laboratory. Laboratory based learning can increase student collaboration so that there is a high interest in participating in learning activities. In MIL learning model is more meaningful because it links new information to relevant concepts contained in students cognitive structure. This concept explains that each student has a cognitive structure that determines the ability of students to handle various ideas and various knowledge. According to Ausubel [5] meaningful learning is marked by the occurrence of relationships between aspects, concepts, information or new situations with relevant components in the

cognitive structure of students. The learning activities with the MIL learning model become meaningful because the teacher explores the concepts students have and helps them harmoniously integrate these concepts with new knowledge.

The post-test scores increased because in the MIL learning model critical thinking skills were developed in each syntax. The first syntax is precondition, critical thinking skills can be developed from opening critical questions that foster interest in learning. Critical questions made by teachers should be analysis that can encourage the cognitive development of students in the learning process. The second syntax is investigation, critical thinking skills can be developed from scientific experiment. Scientific experiment based student worksheet (LKPD) with analysis activities and critical questions that develop students' critical thinking skills. The third syntax is report, critical thinking skills can be developed from the ability to report the results of investigations in critical class discussion. Each grup must be a presentation to the front of the class so interaction occurs between each group. The teacher becomes a facilitator in large discussion activities and provides feedback questions that develop students' critical thinking skills. The fourth syntax is reinforcement, critical thinking skills can be developed from reinforcement quiz. Reinforcement quiz are critical questions and analysis questions that can be students' critical thinking skills. The fifth syntax is reflection, the ability to think critically can be developed from critical reflection from the teacher and make conclusions by students together with the teacher. So critical thinking skills has been covered in all the syntax of the MIL learning model.

3.5. Student Responses to the Meaningful Investigation Laboratory (MIL) Learning Model

Students responses use MIL learning model on static fluid material are shown in table 7.

Table 7. Students responses use MIL learning model

No	Question	Percentage positive responses
1	At the beginning of the learning activity, the teacher's explanation attracts attention.	83,87%
2	Motivation creates enthusiasm for learning.	87,10%
3	The learning process is very interesting.	87,10%
4	I was motivated by the questions in the beginning of learning	80,65%
5	I can better understand the material presented with the experiment	83,87%
6	Teachers always provide assistance to students if they have difficulty in learning.	90,32%
7	Give time for discussions, presentations and other learning activities is in accordance with needs.	80,65%
8	The teacher gives the opportunity to ask all students about material that they do not understand.	80,65%
9	The teacher guides students to make conclusions on learning material.	83,87%
10	I understand the phyisic and was motivated by the practice questions.	87,10%
	Average Percentage	84,52%

Based on the results of student responses use MIL learning model on fluid learning materials get a positive responses with the 84,52% and categorized very good. In learning activities students are very enthusiastic, while use the MIL learning model. Interaction between students and students as well as students and teachers occurs in learning activities use MIL learning model. Because of this interaction can increase the understanding of learning material provided.

4. Conclusions

The MIL learning model was developed from demand for learning innovation in the 21st century. MIL learning model has syntax that is precondition, investigation, report, reinforcement, and reflection. The MIL learning model has a social system, the principle of reaction, a support system, instructional impact, and indirect impact. The results validation of MIL learning models and validation

learning instruments is 92,5% and categorized as valid. There is an increase in students' critical thinking skills after using the MIL learning model is increase with an N-gain value is 0.76 and categorized as high criteria. The critical thinking skills in the MIL learning model developed from every syntax. Critical thinking skills can be developed from: 1) Critical questions in precondition syntax, 2) Scientific experiment with critical thinking student workshhet in investigation syntax, 3) Reporting the results of investigations in critical class discussions in report syntax, 4) Reinforcement quiz are critical questions and analytical problems in the reinforcement syntax, and 5) Critical reflection from teachers to students and make conclusions together in reflection syntax. Students responses use MIL learning model is 84,52% and categorized very good.

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