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Development of Multiple Skill Laboratory Activity Model (MSLAM): An Instrument to Improve 21st Century Skills of Student

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ABSTRACT
This study aims to develop a Multiple Skills Laboratory Activities Model (MSLAM), which can train and develop students' 4C skills (critical, creative, communication, and collaboration) through laboratory activities. This study used the Research and Development method with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. There are 70 students — 18 males and 52 females — who participate in this research. The research instrument consisted of expert validation sheets, tests, and performance assessments. The Likert and Guttmann scale analyzed the MSLAM validation sheet. The test results were analyzed using a normalized gain score <g>, and the performance assessment was analyzed using a Likert scale. The results of expert validation show that MSLAM is very feasible to be implemented in laboratory activities. The test results showed an increase in students' critical and creative thinking skills in the MSLAM group were greater than in the Higher Order Thinking Laboratory/HOT Lab group. Students' communication and collaborative skills in the MSLAM group were greater than in the HOT Lab group. These results indicate that the MSLAM model developed can improve students' 4C skills through laboratory activities. Thus, the MSLAM can be applied in physics learning to develop students' various higher-order thinking skills.

INTRODUCTION

Experiment activity became the important aspect of science learning because it showed how scientist found theory and it can improve much of student's thinking skills [1] [2] [3] such as problem-solving skills [4] [5] [6], creativity [7], learning outcomes and learning achievements [8] [9] [10] [11] and scientific attitudes [1] [12] [13] [14]. Previous studies, related to the development of experimental learning, can be classified into three main topics that are using and developing of analogue equipment/tools [15] [16] [17], using and developing of digital equipment/tools [18] [19] [20] [21] and using and developing of experiment activity model [22] [23] [24] [25].

Developing an experiment tool, analogue or digital is required in order to facilitate collecting data [25] [26]; meanwhile, it is different from the development of experiment activity model that has a function as an outer framework of student activity [27]. Experiment model is a reference for all learning process in the laboratory that was represented as guided or model used by students. Experiment model contains step-by-step activity that students must complete to achieve minimum competencies. However, in fact, models developed have the competencies targeted non holistically ─ one model had one target competence [28] [29] [30]. Meanwhile, there are many competencies in the 21st century that every student should have. Therefore, it needs to design a model that improves any competences by one experiment activity.

The development process has done based on its complexity from the lowest to the highest. Verification or cookbook model, the simplest experiment model, purposed to clarify the concept which has learned in the class [23] [31] [32][33]. Inquiry model is more complex than a cookbook model where students have to generate concept from experiment results [24] [34] [35]. Next, the problem-solving model designed to practice student's problem-solving skills [36] [37] 38] in which students must use concepts, that has been learned in the class, to solve the problems presented [30] [40]. The last developed model was the Higher Order Thinking Skills Laboratory (HOT Lab) that prepared students to find out the concepts at the initial stage and then used them in the last step. So, perhaps, it might be practicing student's ability at higher levels [41] [42] [43]. Meanwhile, HOT Lab model still has any limitation such as step-by-step activity and the tasks which have been resolved when used it to practice any skills simultaneously that seen in.

Based on the description, this research aimed to develop an experiment model that can increase any skills in one experiment activity. The development process was done by focusing on resolving the limitation of HOT Lab Model or to optimize it. The product, namely, Multiple Skill Laboratory Activity Model (MSLAM), was an innovation to increase the student's achievement through experiment activity. Skills that used as referred in this study were to the 21st-century skills, which were known as 4C skills (Critical Thinking Skills, Creative Thinking Skills, Collaboration Skills, and Communication Skills), as the basic competences in facing the 21st century.

METHOD

Research Design

This study used the ADDIE model that has five comprehensive steps which are analyzing, designing, developing, implementing and evaluating [44] [45]. Analyzing steps were the phase to analyze the necessity, feasibility, and type of school laboratory activity. In analyzing stage, the data collected from 82 teachers and used them to define what laboratory problems must be resolved, but this is not the focus of the research. Besides, this phase also provides a highlight of documents and materials through the current curriculum. In the design process, researchers decided MSLAM consist of three phases, called pre-laboratory, laboratory, and post-laboratory. Besides, researches were also decided electric current as used content. After that, MSLAM was developed based on repaired indicators of HOT Lab. MSLAM has 13 steps which are 1) real world problem, 2) experimental questions, 3) brainstorming, 4) ask an alternative idea, 5) conceptual questions, 6) predictions, 7) materials and equipment, 8) exploration, 9) measurements, 10) analysis, 11) conclusion, 12) presentation and 13) evaluation and reflection. In the last stage, students, 16 groups with eight groups in experiment class and eight groups in control class, used MSLAM and HOT Lab in their laboratory activity for four months. And then, they take the test to measure their ability in each of 4C skills.

Participants

There are 70 students ─ 18 males and 52 females ─ who participate in this research. Participants are the third-year students in Physics Education Department UIN Sunan Gunung Djati Bandung, Indonesia that spread into 16 groups randomly. Participants were believed heterogeneous on necessary competencies and intellectual capability.

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Instruments
The instruments have been used including validation sheet, filled by five experts in three concentrations which are learning media, physics content/material, and language, a test of critical thinking skills, a test of creative thinking skills, and observation sheet to analyze student collaborative and communication skills. Indicators of critical and creative thinking were modified from Binkley & Tiruneh and Torrance & Almeida framework [46] [47], while the communication and collaboration indicators modified from Levy and Trilling & Fadel framework [48] 49].

Scoring
The validation sheet was scored by using 5-point Likert scale which is strongly approved, approve, undecided, disapprove, strongly disapprove, and experts recommendation or suggestion for improvement [50]. Experts assessed MSLAM in two aspects which were didactic requirements and construction requirements [52] [52]. Besides, the experts were also assessing the validation of test instruments using 2-point Guttmann scale, 1 to appropriated and 0 to unappropriated, for three aspects which were the suitability between aspects of the skills and the questions, the relevance between indicators and problems, and the appropriateness of the answer key to the subject [53]. Then, scoring of student's test results for critical thinking skills and creative thinking skills used a 4-point Likert scale based on rubric assessment. Student's answers are scored four for totally correct, three for partial correct, two for partial incorrect, and one for incorrect answer. Then, scoring performance for communicative and collaborative thinking skills used a 4-point Likert scale referred to rubric assessment. Rubric scored four if students did all steps well, scored three if students did most levels well, scored two if students did some steps well, and scored one if students did most steps unwell. In the end, every scoring result transformed to 0-100 scores.

Data Analysis
The data analyzed using two approximation based on its sources. Firstly, the data of the validation instrument was used to get information about the quality of MSLAM, and the tools applied. There were including the validity of MSLAM, the validity of the critical and creative thinking test, the validity of the communication and collaboration achievement sheet. Then, the result interpreted based on criteria [24] [54]. Secondly, the data from the student's result test and achievement performance was analyzed using normalized gain <g>. Then, these result interpreted in its gain levels [55].

RESULTS AND DISCUSSIONS

These results will be presented through the ADDIE model, which are Analyzing, Designing, Developing, Implementing and Evaluating.

Analyzing
In this stage, researches have analyzed laboratory activities to find the problems, limitation, and chance to be developed. Finally, we found some issues have been to solve. This result showed that the most important problems to be solved were experiment tools and compatible model. So, in this study, we tried to solve problems related to the compatible model by analyzing indicators from previous models [42] [56] [57] in Table 1.

Table 1. Analysis of Stages of Implementing Various Models of Laboratory Activities

No	Indicators	VBL	IBL	PSL	HOT Lab
1	Real-world problem	-	-	V	V
2	Experimental question	V	V	V	V
3	Brainstorming	-	-	-	V
4	Propose alternative ideas	-	-	-	-
5	Conceptual questions	V	V	V	V
6	Prediction	V	V	V	V
7	Material and equipment	V	V	V	V

No	Indicators	VBL	IBL	PSL	HOT Lab
8	Exploration	-	V	V	V
9	Measurement	V	V	V	V
10	Analysis	V	V	V	V
11	Conclusion	V	V	V	V
12	Presentation	-	-	-	V
13	Evaluation and reflection	-	-	-	-

Note:
VBL: Verification Based Laboratory
IBL: Inquiry Based Laboratory
PSL: Problem Solving Laboratory
HOT Lab: Higher Order Thinking Laboratory

According to Table 1, the development of experimental models complements the limitations of previous models. Based on the item completeness of the activity, the last model developed, the HOT Lab model, has limitations in terms of presenting alternative ideas where students can submit ideas other than the options provided. In addition, the HOT Lab Model also does not have a series of activities in the form of evaluation so that the completeness of a learning process looks lacking. It is based on three main components in learning activities, namely planning, process, and evaluation [56] [57].

Designing

Analyzing results indicated several activities or steps that will solve the limitation of previous models that are adding two-step in HOT Lab model. These steps are “Discussing Ideas” supporting the propose alternative ideas indicator and “Evaluating and Reflecting” encouraging the last signs in Table 1. “Discussing Ideas” aimed to give a chance to the student to serve other solutions, not stated in the model, then can solve the problems implied in the model in order to make students more creative. “Evaluating and Reflecting” step was the last step where teacher and students, together, review what they were learned. The teacher confirmed what student found in the experiment in the case to avoid misconceptions and to explain the difference result of the students. For more detail, the step-by-step of MSLAM are shown in Table 2.

Table 2. Step-by-step MSLAM Activities

No	Indicators	Student Activity
1	Real-world problem	The student independently analyzed and decided the idea to solve the problems
2	Experimental question	The student individually answered the questions from the model
3	Brainstorming	Students in the group discussed their idea
4	Propose alternative ideas	The student in their group was able to add other ideas
5	Conceptual questions	The student independently examined every thought in their group by answering the question
6	Prediction	Students regardless predicted his/her opinion and tried to predict by using other purposes in his/her group.
7	Material and equipment	Students in the group prepared the material and equipment to examine their solution, just for one solution selected.
8	Exploration	Students in the group set the tools to examine their solution
9	Measurement	Students in the group collected data from the experiment
10	Analysis	Students in the group analyzed the data to solve the problems
11	Conclusion	Students in the group concluded the idea that used to solve the problem and the result of the experiment
12	Presentation	Students in the group presented what were they did and what where they got.
13	Evaluation and reflection	Teacher or another student confirmed the result of each group and made the last conclusion.

Developing

The development stage of each indicator and student activity were designed into MSLAM at electrical current content. In this stage, Model and instruments were also validated using three aspects, as seen in Table 3, Table 4 and Table 5.

Table 3. Results of Validation Models of Multiple Skills Laboratory Activities

No	Aspect assessed	Validator (%)					Average (%)	Criteria
		I	II	III	IV	V		
1	Didactic requirements	89	80	83	74	80	81	Good
2	Construction requirements	86	88	83	82	84	84	Very good
	Didactic and construction requirements	87	86	83	80	84	84	Very good

Table 3 is the result of the assessment of five validators. The average score of didactic for requirements reached 81.00% with good criteria, and for construction, requirements reached 84% with very good criteria. Overall, the average score reached 84% indicating this model has very good criteria. Based on the criteria, the average score intended for two aspects of the assessment, namely didactic requirements and construction requirements, it can be concluded that this model might be used in college or school [54]. The results of this validation indicate that the developed model can be accepted both didactically and constructively.

Table 4. The Recapitulation Results of the Validation of Test

Aspect	Percentage skills score		interpretation
	Critical thinking	Creative thinking	
The suitability of aspects of the skills with the questions	100	100	Accepted
The suitability of the indicator with the questions	100	100	Accepted
The suitability of the answer key to the question	100	100	Accepted

Based on Table 4, instruments of the test were possible to use in the learning. From 100% score in both thinking skills, these instruments were accepted able to measure the competencies of students [58] For critical and creative thinking instruments, it is a test instrument in the form of questions related to indicators of critical thinking and creative thinking skills. This instrument is declared conceptually feasible based on expert agreement through the resulting validation sheet [59].

Table 5. The Recapitulation Results of the Validation of the Performance Assessment

Aspect	Percentage skills score		Interpretation
	Communication	Collaborative	
The suitability of aspects of the skills with the statements	100	100	Accepted
The suitability of the indicator with the statements	100	100	Accepted
The suitability of the answer key to the statements	100	100	Accepted

The instrument for communication and collaboration skills is in the form of observation sheets. There are seven indicator statements presented in the collaboration ability observation sheet consisting of 1) Contributing actively to the group; 2) Collaborate with different types of people; 3) responsible for completing tasks; 4) management of group assignments; 5) cooperate, accept suggestions and joint decisions; 6) show respect for friends or team; and 7) adapting to various roles in the group. Furthermore, in scientific communication skills, four aspects that are used as references for instrument development are scientific writing, information representation, and knowledge representation. Based on the results of validation by experts, performance assessment instruments were 100% of acceptable [60] [61].

Implementing

In the implementation stage, students did experiment activity and filled the Model. Furthermore, the student was also tested and observed to analyse their thinking skill and their performances. The result of the student's critical thinking skills and student creative thinking skills shown in Table 6 and Table 7.

Table 6. The Average of Gain Normalised of Critical and Creative Thinking Skill

Skills	**(N-gain)**		**Criteria**	
	Experiment	**Control**	**Experiment**	**Control**
Critical thinking	0.84	0.53	High	Medium
Creative thinking	0.81	0.51	High	Medium

The students in the experiment class have a higher level of enhancement than the students in the control class. The experiment class was using MSLAM, and the control class was using HOT Lab. The average score in experiment class is 0.825 with the high criteria and in the control class was 0.52 with medium criteria [55].

Table 7. The Achievement of Communication and Collaboration Skills in Each Group

Skills	**Experiment (%)**	**Control (%)**
Communication	65.70	55.12
Collaboration	65.00	57.00

The students' performance results in Table 7 is also showing that students in the experiment class were better than students in the control class. However, that is not a significant difference where the average score in the experiment class is 65.35, while the average score in the control class is 56.06.

Evaluating

This research was conducted to increase student's skills and to improve the previous model by fixing its limitation. However, this research still found several obstacles, including: 1) Time management to carry out laboratory activities of multiple skills models in various stages (pre-laboratory, laboratory, and post-laboratory) required discipline; 2) Students' understanding of related concepts to solve real-world problems needs to be improved; 3) The evaluation and reflection phase is not optimal because some students are still confused about what to write on the reflection sheet; 4) For further development, researches provided the suggest of this research that can be done as follows: 1) The teacher should check and make sure students have done all the work in the pre-laboratory stage that has been done before doing the laboratory stage; 2) Students are encouraged to master concepts related to real-world problems by being more diligent in reading and seeking information from various references. Students are given the opportunity to express what has been understood

Discussion

ADDIE process has been used to develop Multiple Skill Laboratory Activity Model (MSLAM). According to the analysis stage, teachers, facilitators at school, needed a guide or model experiment that supported the learning process to achieve many competences of the curriculum. The guide needed is an integrated Model. Integrated model made the learning process more effective to practice any skills [62] [63]. Then, researches designed a new model referring to HOT Lab model as the last developed laboratory model by adding several steps such as “propose alternative ideas” and “evaluation and reflection”. Propose alternative ideas aimed to provide opportunities for students to develop their creative thinking skills [64]. Evaluation and reflection step was crucial to know the impressions and problems found by the students from the learning [65]. In addition, for the teacher, this step can be used to give reinforcement related topics, so the student will not have misconception anymore [66].

Based on Table 3, MSLAM has good appreciation in which didactic aspect has an average percentage of 81%. Its mean, MSLAM was a functional model to deliver and guide students. Another result showed that the construction aspect MSLAM has 84% average score that means the Model will be able to practice students skills [66] [67] [68]. Based on Table 4 and Table 5, that show experts assessment of thinking skill test and performance assessment, it can be concluded that all of the instruments were available to use in measuring students competencies such as critical, creative, communicative, and collaborative [66] [69] [70] [71]. In the result of student’s responses, it can be concluded that students in the experiment class were better than did students in the control class. Students in experiment class are always having higher score in every competence. In the critical thinking skills result, experiment class had the gain score 0.84 > 0.53 in the control class. The same effect shown in creative thinking skill was in experiment class had gain score 0.81 > 0.51 in the control class. The result of performance assessment is the same as the thinking skills. Based on Table 7, students in the experiment class is more dominating than students in the control class. There are 65.35% of experiment activity can be done well by a student in experiment class. It is higher than the control class, which is only 56.06%. According to previous research, this is due to several factors, including the length of study and the type of learning activities. Students in MSLAM have more portions of learning and activities than HOT Lab model [66] [67] [68] [69] [70] [71] [72] [73] [74]. Based on this result, it can be concluded that all stage on MSLAM with includes add the step of “propose alternative ideas” and “evaluation and reflection” proven to improve 4C skills of students.

CONCLUSION AND SUGGESTION

Based on the development process and test results, it can be concluded that MSLAM is a model guiding the students to achieve the 4C skill in laboratory activity. As the HOT Lab model improved, MSLAM has didactic and construction requirement’s average scores of 81% and 84%. The test results showed an increase in students' critical thinking skills by 0.84 in the MSLAM group and 0.53 in the HOT Lab group. The increase in students' creative thinking skills in the MSLAM group was 0.81, greater than that in the HOT Lab group of 0.51. Students' communication skills in the MSLAM group 65.70%, and the HOT Lab group 55.12%. Student collaboration skills in the MSLAM group scored 65.00%, and the HOT Lab group scored 57.00%. These results indicated that the MSLAM instrument could be used as a reference for further research to practice any skills in one experiment activity.

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