



## PROBLEM-SOLVING ABILITY OF SCIENCE STUDENTS IN OPTICAL WAVE COURSES

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### ABSTRACT

Optical wave courses at the Department of Science discuss waves and optics. The purpose of this study is to describe the problem-solving ability of students in optical wave courses. The method used is quantitative descriptive with one group pre-test post-test design. Method of data collection involves a test given to students before and after the student worksheet was provided in the course of optical waves. This study showed an increase in scores experienced by as many as 15 students. This shows that the problem-solving ability of students has increased.

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**Keywords:** problem-solving ability; waves and optics; student worksheet

### INTRODUCTION

Science learning has three important dimensions that must be developed namely basic concepts and knowledge of science, process skills, and scientific attitudes so that science learning in schools can apply scientific methods by familiarizing students doing scientific work (Rahayu et al., 2012). The basic concept and knowledge of science is the most fundamental in learning and teaching science. While process skills occur naturally by using logic to describe the steps in the thinking process to find out the answers to the questions that occur in the environment. Scientific process skills are not only used to solve problems related to science but can be applied in other situations in everyday life. This process skill requires critical thinking skills and problem-solving skills. Skills of this science process include observing, counting, classifying, inferencing, predicting, conducting experiments,

and communicating. Thus it is important for prospective science teachers to master the skills of the science process, in this case the problem-solving ability to implement optimal science learning in the classroom.

There are several educational philosophies that can be used by science teachers to optimize students' achievement in science learning. One of them is using a problem-solving approach that implements inquiry learning in it (Hake, 1998). Teachers' duties and roles are not only as information givers, but also as a driver of learning so that students can construct their own knowledge through various activities that demand the active role of the students. This is in contrast to conventional learning which implement teaching-centered learning activities, where the teacher only explains the material, gives examples of problems, then gives the exercise of a question which is usually similar to the example of a given question. The provision of complex and contextual issues will assist students in training their physics problem solving abilities (Sujarwanto et al., 2014). Until now, efforts made to improve the

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quality of education still have not shown optimal results, especially in the course of Optical Wave. It is because the lecturing process only gives lectures and discussions. While students are working on problem-solving problems, they faced difficulties so that they obtained low score.

Learning should provide a learning experience for students through scientific work. Scientific work is a way of solving problems with a series of sequential or systematic activities (Wasis & Irianto, 2008). Activities in scientific work require the use of the ability of the process of science, including: observing, classifying, communicating, measuring, predicting or forecasting, and concluding. However, the optical wave lecture that has been implemented in the IPA Department is still very limited by only providing Student Worksheet (LKM) for the refraction and reflection material. This is not in accordance with the coverage of optical wave materials which include waves, sounds, and optics. In addition, the existing student worksheet model in this lecture is a form of student worksheet that facilitates students in conducting experiments, but limits the ability of students in finding problem solving independently.

Problem-based learning begins from everyday authentic problems from real and meaningful life (Herawati et al., 2010). The problems of science learning (including physics, biology, and chemistry) are related to three aspects namely, creativity, teaching materials, and science process skill (Wenno, 2010). The problems of science are ideas which play important roles in building the capacity of students' problem-solving skill and make science teaching become more joyful and it is able to motivate students to have more achievement (Arimbawa et al., 2013). Problem-solving skill is not only used to solve science problems in the form of mathematical forms but also it is used to solve problems in surrounding environments (Hertiavi et al., 2010). Some experts stated that problem-based learning helps students improve thinking skill, problem-solving skill, and intellectual skill. It also helps them improve cooperating skill and their students' social attitude (Susilo, 2012). The learning model using real problems found in surrounding environment can be used as the basic to gain knowledge and concepts through critical thinking skill and problem solving skill (Fakhriyha, 2014). Thinking means using analytical, creative, and practical ability. That intelligence is needed in everyday life. High-level thinking skill like metacognitive skill is a part from high-level thinking skill (Widodo & Kadarwati, 2013).

Five stages of solving problems according to Krulik and Rudnick (Carson, 2007) are

as follows, 1) Reading. The activities undertaken by this stage are to record keywords, ask other students what is being asked on the problem, or restate the problem to a more easily understood language. 2) Exploring by including searching patterns to determine the concept or principle of the problem. At this stage, it identifies a given problem, presenting the problem into an easy-to-understand way. The question used at this stage is, "what kind of problem is it"?. This stage is usually done by drawing activities or creating tables. 3) Choosing or selecting a strategy. At this stage, drawing conclusions or hypothesize about how to solve the problems encountered based on what has been obtained in the first two stages. 4) Solving the problem. At this stage all the calculating skills are performed to find an answer. 5) Reviewing and discussing (reviewing and extending). At this point, the students double check the answer and see the variation of how to solve the problem.

There are four stages of problem solving skills according to Selcuk et al. (2008) 1) understanding the problem, 2) planning the completion, 3) implementing problem solving based on the plan and 4) re-checking (Selçuk et al., 2008). Problem-solving is a process to find a combination of a number of rules that can be applied in an effort to cope with the new situation. Troubleshooting is the process of getting a set of rules at a higher level. If a person has gained a combination of devices that are proven to be operable in accordance with the situation at hand, he is not only able to solve a problem but also succeed in finding something new that is a set of procedures or strategies that allow one to increase self-reliance in thinking (Gagne, 1985). Based on the above description, a research was conducted with the title "Problem Solving Ability Student IPA on Optical Wave Course". Problems to be answered in the research is how to improve students problem solving abilities in the discussion of waves and optics after the implementation of the student worksheet? The objective of the research is to describe the improvement of problem solving ability of IPA students in the discussion of wave and optics after the implementation of student worksheet.

## METHODS

This type of research is descriptive quantitative. The subjects of the study were students of IPA class of 2013. The research design is one group pre-test post-test.

**RESULTS AND DISCUSSION**

$$O_1 \text{-----} \rightarrow X \text{-----} \rightarrow O_2$$

(Sugiyono, 2013)

Information:

$O_1$  = score of *pre-test* (before treatment)

$O_2$  = score of *posttest* (after treatment)

X = treatment with the implementation of learning with the student worksheet to train problem-solving skills

The research instrument is a test sheet. Methods of data collection are tests given to students before and after the student worksheet. The test is given in the optical wave course. The purpose of the test method is to determine the problem-solving ability before and after using the student worksheet. The test of problem solving ability is adjusted to the achievement of the component of training problem solving abilities including 1) understanding the problem of writing the problem formulation, 2) planning the completion of preparing the hypothesis, determining the variables and designing the experiment 3) implementing the problem-solving skill based on the plan which include collecting data, analyzing, and concluding, 4) rechecking the results obtained.

The standard of success of each student is seen from the mastery of learning objectives.

$$\text{Score} = \frac{\text{Score Obtained}}{\text{Maximum Score}} \times 100$$

The results of the analysis of students' problem-solving capability will be used to determine the feasibility of the student worksheet developed by using the following interpretations:

**Table 1.** Criteria of Score Interpretation of Problem-Solving Achievement

Percentage	Criteria
20 % - 40 %	Bad
41 % - 60 %	Medium
61 % - 80%	Good
81 % - 100 %	Very Good

(Riduwan, 2010)

To find out the problem-solving capability, the following formula is used:

$$g = \frac{(post-test) - (pre-test)}{4 - (pre-test)}$$

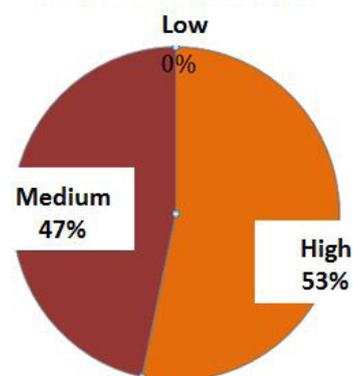
The result of problem solving capability is analyzed using gain score that can be seen in Table 2.

**Table 2.** Achievement of Problem-Solving Ability based on Gain Score Analysis

SRN	Pre-test	Post-test	Gain Score
13030654041	10	61	0,57
13030654042	7	82	0,81
13030654043	17	84	0,81
13030654046	13	60	0,54
13030654047	14	83	0,80
13030654049	0	92	0,92
13030654050	56	83	0,61
13030654051	0	73	0,73
13030654052	7	92	0,91
13030654053	13	70	0,66
13030654054	14	61	0,55
13030654055	19	84	0,80
13030654056	24	88	0,84
13030654057	10	46	0,40
13030654058	7	61	0,58

Table 2 shows that students are improving. The diagram below shows the gain score which includes high, medium and low criteria.

**Percentage of Improvement of Problem-Solving Ability**



**Figure 1.** Percentage of Improvement of Problem-Solving Ability

This shows that the improvement of students problem-solving skills are experienced by 15 students. It indicates the feasibility of this

student worksheets seen from the high criterion percentage (53%), moderate (47%) and low (0%). Factors that cause students with various criteria are because students have different levels of intelligence compared with other students. Moreover, while learning, they have difficulty in implementing problem solving in the plan. This is based on the result of the test done by the students (pre-test and post-test) which showed that the problems in the level of analysis cannot be solved by the students well. In order to perform the process analysis well, first the student must have the ability in interpreting the data well. Achievement of problem solving component of pre-test result is presented as follows.

**Table 3.** Percentage of Components of Pretest on Problem-Solving Ability

Components of Problem-Solving Ability	Percentage (%)
Understanding Problems	33,33
Planning Solution	6,67
Execusting the solution based on planning	0
Rechecking	0

Post-test results of the components of problem solving abilities are presented as follows:

**Table 4.** Percentage of Problem-Solving Components

Components of Problem-Solving Ability	Percentage (%)
Understanding Problems	100,00
Planning Solution	93,33
Execusting the solution based on planning	73,33
Rechecking	66,67

In Table 3 and Table 4, the difference in achievement of components of problem-solving capability shows that students in understanding the problem achieved 100%. It reveals that students can write the problem formulation appropriately. Planning completion scored 93.33% which reveals that the students can almost all compile hypotheses, determine variables and design experiments. Components stating that students are able to implement problem-solving based on plan (collecting data, analyze and conclude) scored 73.33%, because there are students making mistake in making table and graph. The last component is rechecking seen from the results of students' work and writing amount and

unit exactly. The component scored 66.67%. A Part of the students forgot in writing the unit in completing the work. From the observation of student activity in doing the student worksheet, students cannot optimally do the assignment. The way to package good material is in the form of an student worksheet constructed by constructivist principles (Prastowo, 2011).

Mason & Singh (2011) stated that someone who has a high ability in problem solving is able to recognize the concept of the problem. The theory of constructivism by Vigotsky said that by conducting a constructivism process by finding and building the concept of knowledge they have learned, we can improve students' understanding of a concept to be learned (Nursalim, 2007). Based on the theory, problem-solving student worksheets can condition students to use information or knowledge that has been studied to understand new concepts. The results of research show that students find it easier in understanding the Optical Wave course after being treated by student worksheet problem-solving. It is shown by the existence of significant difference between pre-test result with post-test. In addition to the above theory, the results of this study are also supported by Sudirman (2000) who said that, the purpose of applying the problem solving method is to obtain students' cognitive abilities and cognitive skills so that students' ability in mastering concepts, principles and generalizations improves.

## CONCLUSION

The study concluded that the increase of score is experienced by eight students. The improvement includes high criterion (53%), 7 students are included in medium criterion (47%), and no student is included in low criterion (0%). This suggests that problem-solving abilities has increased by 100% after a problem-solving student worksheet.

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## THE DEVELOPMENT OF INQUIRY BY USING ANDROID-SYSTEM-BASED CHEMISTRY BOARD GAME TO IMPROVE LEARNING OUTCOME AND CRITICAL THINKING ABILITY

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### ABSTRACT

Student's critical thinking and their learning result depend on learning design and student's activity. Most students use their spare time with playing game. Students are more challenged by the difficulty in playing game rather than facing the difficulty in understanding the lesson. This phenomenon is the basic reason of the researchers to develop a game that has the essence of the subject matter, namely Chemistry Board Game (CBG) or we can call it with Al Chemist Knight. This research aims to develop a suitable digital game based on android system. In this research media was used to improve the cognitive learning and critical thinking. It also has purpose to evaluate the response of learners in learning chemistry through alkane derived compound topic. The development of this game was adapted from the procedure of game development process in mobile 3D presentation. The collection of evaluation data model applied was pre test and post test in trial class. The result showed that in the pretest the learning result average was 34.35 with classical target of 5%. While the posttest learning result average was 80.51 with classical target of 85%. The n-gain factor was 0.703. Based on the result of the students questionnaire data analysis, 3.025 of students responded positively to the implementation of CBG. A CBG media makes an assessment of critical thinking, in which the indicator of critical thinking which are focusing on questions get 3,1 point, giving arguments get 2.95, asking and answering questions get 3.0, making decision get 3.05, and the average score of critical thinking indicator is 3.025 which belongs to good category. Based on the students' response questionnaire, we get the average score of 3.3 or 82.5% which is classified in good category.

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**Keywords:** chemistry board game; inquiry; critical thinking; learning outcome

### INTRODUCTION

The 21<sup>st</sup> century is a century of knowledge, where information is scattered and technology evolves. The characteristic of the 21<sup>st</sup> century is the increasingly interconnected world of science, so that the synergy between them becomes faster. The context of the utilization of information and communication technology in education is evidenced by the melting factor of "space and time" has been a determinant aspect of the speed and success of science by mankind. The 21<sup>st</sup> century

is marked with the abundance of (1) information available anywhere and accessible at any time; (2) faster computing; (3) automation that replaces routine jobs; and (4) communication that can be done from anywhere and everywhere.

The 21<sup>st</sup> century skills can help students to learn and adapt to all forms of change that takes place over time (Ongardwanich et al., 2015). The change is related to global economic, ecosystem and political networks. This condition requires students to learn how to communicate, cooperate, and solve problems with people all over the world. Students need seven survival skills including: critical thinking and problem solving,

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leadership and cooperation, agility and adaptability, full of initiative and enterpreneur spirit, ability to communicate effectively both oral and written, easy access to information and information analysis, imagination and curiosity (Saavedra & Oper, 2012).

A 21<sup>st</sup> century learning framework that requires learners to have the skills, knowledge and skills in technology, media and information, learning and innovation skills as well as life and career skills. This framework also explains the skills, knowledge and expertise that must be mastered so that learners can be successful in life and work. In line with that, the 21<sup>st</sup> century learning paradigm emphasizes on the learners' ability to find out from various sources, formulate problems, and do analytical thinking and cooperation as well as collaboration in solving problems. To deal with learning in the 21<sup>st</sup> century, everyone must have critical thinking skills, digital literacy knowledge and skills, information literacy, media literacy and master information and communication technologies (Jagodziski & Wolski, 2015).

The mastery of the 21<sup>st</sup> century is supported by students' critical thinking skills. Critical thinking is a skill that deals with disposition. Critical thinking as well as creative thinking, being a critical thinker not only has a certain cognitive, but also a willingness to assess and evaluate information critically. Critical thinking generally involves the identification analysis of issues and assumptions. The practice of critical thinking requires an analysis on how arguments and thoughts are constructed so as to produce a formula or conclusion (Vellalba, 2011).

Critical thinking is to think seriously, actively, and accurately in doing the analysis of all information received with a rational reason. (Liberna, 2011). Critical thinking is used in making judgments of information and explaining the reasons for problem solving (Thomas, 2011). Critical thinking has an important role in determining decisions and overcoming problems during the learning process and in everyday life (Snyder & Snyder, 2008). Critical thinking is necessary to address the problems faced in life. By thinking critically, one can organize, adjust, change, or fix his mind so that he can act more appropriately. A critical thinker is a man of skillful reasoning, a critical thinker uses his reasoning as his rationale (Kartini, 2012).

Critical thinking will be easier to teach to students if it is included in the course, as opposed to practicing critical thinking independently through critical thinking courses (Ennis, 2016). Critical thinking skills are very important to de-

velop because learners can more easily understand the concept, sensitive to problems that occur so as to understand and solve problems, and able to apply the concept in different situations. Critical thinking learned in the science class also affects learners' lives long after they leave formal education by providing tools that can be used to analyze many issues they face in their daily lives. Critical thinking can be developed in learning by enriching meaningful learners' experiences. The experiences can be in form of an opportunity to argue verbally or in writing like a scientist (Frydenberg, & Andone, 2011).

The research and development that had been done by (Khasanah et al., 2017) stated that student's critical thinking skills increased by using the respiration module which was developed based on the critical thinking indicators so that student's learning outcome improved. The process of critical thinking skills is developed through inquiry learning. This is because in the process of inquiry, learners receive information, they will think, prioritize the information, and search for its correlation before looking for supportive reasons that refer to the new knowledge. Subsequently they will be drawing up learning plans and diverse activities then stimulating them, and asking questions to improve brain thinking skills is an inquiry learning process (Llewellyn, 2002).

Inquiry learning is applied to chemistry subject. Chemistry is a science subject in which its application is close to everyday life (Bailin, 2002). One of the chemistry materials taught in senior high school related to the utilization of chemicals in everyday life is the alkane derived compounds material. This material is the basic material of organic chemistry in which its development and application is so vast and related to real life of society. Alkana derived compounds are memorizing material with abstract concepts. The learning activities are monotonous, which leads to boredom and results in low student scores.

Several studies have committed in the development of educational games to support the teaching of basic 21<sup>st</sup> century skills (Boyle et al., 2014). Game based learning describes an environment that contains materials game and a game of knowledge and skills to gain score in which this game activity involves problem solving skills and challenges to students with a bit of disappointment (Kirriemuir & Mcfarlane, 2004).

The use of Chemkarta games in chemistry learning increases the knowledge and learning outcomes of students on the functional group material (Knutson, 2015). The study states that

the use of games in chemistry learning will help students in learning the material, so that students learn with fun and increased understanding.

The current review analyzes the impact of the use of Game Based Learning (GBL) on the development of 21<sup>st</sup> century learning skills in depth and reveals that the effectiveness of GBL relies on game design. In particular, game design featuring the mixing of learning theories with game design elements proved to be successful (Libema, 2015). The game industry leads to effective learning. Game and learning materials design based games tend to work better than just games that contain educational or entertaining matches only. In summary, this study demonstrates the reason for optimism about the potential for using game based learning as an approach to promote the development of 21<sup>st</sup> century skills in the future (Qian & Clark, 2016).

The approach of digital technology using as a learning medium has a better and more effective impact than other approaches. To increase students' interest in learning, an interesting learning media support is needed. The use of gaming applications as learning media can increase learning outcomes (Adnan et al., 2017).

From the results of interviews conducted, it can be seen that nearly 90% of learners spend their spare time by playing games on their android phone. The potential for playing game liking can be utilized for learning process through making android based chemistry board game. Learning methods and media applied by teachers so far have not accommodated the potential of learners in playing the game. Therefore, there are still many learners who are supposed to take more time to study only waste their time. The integration of inquiry method in learning using games has not been developed so the researchers try to combine inquiry method with android-based game media. This merging of method and media is expected to provide an alternative in teaching chemistry to learners.

The purpose of this research is to 1) Knowing the level of validity of interactive media android base Chemistry Board Game on alkane derived compound material; 2) Knowing and describing the effectiveness of Chemistry Board Game media which can be used to improve the critical thinking ability of class XII-IPA students; and 3) Knowing and describing changes in mastery level of learners' material which is seen from the learners' learning outcome on alkane derived compound material after using this media.

The approach used is inquiry. The Inquiry approach teaches students how scientists work.

This approach can motivate students to become thinkers, grow curiosity, train in cooperation and solve problems (Widowati et al., 2017)

According Gulo (2002) explains the inquiry stages to be done as follows:

a. Identification and clarification of problem

The first step is determining problem to be explored or solved by inquiry method. Issues can be prepared or submitted by the teacher. The nature of the class problem so that can be thought, experienced, and solved by students. Issues need to be identified and clarified. If the problem is determined by teachers, it needs to be noted that the problem should be real, can be done by students, and in accordance with the ability of students. The issue corresponds to the level of life and state of the student.

b. Formulating hypothesis

The next step, students are asked to submit a temporary answer about the issue. This is called the hypothesis. Student hypothesis is evaluated by the teacher if it is not appropriate and clear then the teacher helps to correct it by clarifying the purpose only. A false hypothesis will later be evident after data collection and analysis of data obtained.

c. Collecting data

The next step, students search for and collect data to prove whether their hypothesis is true or not. One way to collect data can be done by practicum.

d. Analyzing data

The data collected should be analyzed to be able to prove whether the hypothesis is true or not. To make it easier to analyze, data should be organized, grouped, and managed so that it can be analyzed easily. The data are usually arranged in a table for easy reading and analysis. Here sometimes teachers need to intervene because of there are lots of data that students are sometimes confused to determine the next step. In analyzing, it is often necessary to use calculation tools such as mathematical formulas and statistics that allow students to make decisions or take generalizations.

e. Drawing conclusion

From the data that have been grouped and analyzed, the conclusion is drawn with the generalization. After drawing conclusion, it is then matched to the original hypothesis, to see whether our hypothesis is accepted or rejected.

The inquiry process begins with formulating problems, developing hypotheses, gathering evidence, testing hypotheses, and drawing temporary conclusions, examining temporary conclusions to get conclusions that to some extent are believed by students (Hasnunidah, 2012). Chemistry board game learning media to be developed in the form of audiovisual media is a set of tools that can project moving and voicing images. The combination between image and sound shapes characters equal to their original form. Computer based chemistry board game learning media is one of the media that can create an interactive teaching environment that provides an active response to the learning needs of students by preparing effective learning activities to ensure the occurrence of independent learning (Arsyad, 2011).

Interactive concepts in a computer-based learning environment follow three elements, namely (1) adjustable instructional sequences; (2) student work responses or answers; and (3) adjustable feedback. Learning using this interactive media has a positive impact on learning. The use of computer-based learning media in addition to improve learning outcomes, it also increases the role and skills of students' knowledge (Sadiman, 2010). The learning media used also affects the ability of students to search and investigate new knowledge (Akhliis & Dewi, 2014).

Critical thinking is a well-directed and clear process used in mental activities such as problem solving, decision making, persuading, analyzing assumptions, and conducting scientific research. Critical thinking allows students to systematically study the problem, face a multitude of challenges in an organized way, formulate innovative questions, and design solutions (Kartimi, 2012).

Critical thinking is a systematic process that allows students to formulate and evaluate their own beliefs and opinions. Critical thinking is an organized process that allows students to evaluate evidence, assumptions, logic and language that underlies others' statements. Critical thinking is also thinking well, and contemplating the thought process is part of thinking well (Fitriawati, 2010).

Critical thinking is grouped into five main activities as follows:

- a) Providing a simple explanation, which contains; focusing questions, analyzing questions and asking questions, and answering questions about an explanation or statement.
- b) Building basic skills, which consists; considering whether the source is trustworthy or not and regarding and considering an observation report.

- c) Concluding which consists of deducting activities or considering the results of deductions, inducing or considering induction results, and making and determining the value of consideration.
- d) Providing a further explanation which consists of identifying terms and definitions of considerations as well as dimensions, and identifying assumptions.
- e) Setting strategies and techniques which consists of determining actions and interacting with others (Ennis, 2016).

## METHODS

Research and development of interactive learning media Chemistry Board Game or also called Al Chemist Knight was done in SMA-IT Al Irsyad Al Islamiyyah Purwokerto. The location of the research was chosen in SMA-IT Al Irsyad Al Islamiyyah Purwokerto because the result of observation and experience as a teacher in the school found that the use of learning media as a source of learning is rarely used while it is based on observation and interview of students' needs then the students need an easily accessible learning media from anywhere.

Preliminary research was conducted in the early stages of the study by doing observations and interviews on teachers and students as well as school management, especially the vice principal of the curriculum field. After developing an interactive media development design that has been validated by the experts, the researchers conducted small-scale test. Product trials were conducted to the students of class XII-IPA with alkane derived compound material in the odd semester of the academic year 2016-2017. This research was planned to begin on July 25, 2016 up to September 30, 2016.

There were two different types of trials with different grades in one school. Small-scale trial was done to the students of XII-IPA1 class as many as 10 students that were taken randomly. Large-scale trial was done to the students of XII-IPA2 as many as 20 students.

This research is a Research and Development (R & D) study conducted to develop learning media Chemistry Board Game (CBG) named Al Chemist Knight in which the application of this media is combined with inquiry learning model, on chemistry subject by taking the specification of organic chemistry material, a functional group of alkane derived compounds (the material of XII class of senior high school). The development procedure of the Game Development Process on mobile 3D presentation from Perdue Uni-

versity was later translated into detailed research procedures.

Data sources of this research and development are derived from the research subjects which are students of XII-IPA Class of SMA-IT Al Irsyad Al Islamiyyah especially class XII-IPA1

and XII-IPA2, as well as the chemistry subject teacher who plays a role in the learning process at school. Not to mention, the Principal and Administrative staff who permit and assist the on-going research.

**Table 1.** Data form, Data Collecting Method, and Instrument

Data	Data Collecting Method	Instrument
The potential identification and the validation of <i>chemistry board game</i>	Interview for teacher and students Product validation by the experts and chemistry teacher of SMA-IT Al Irsyad Al Islamiyyah Purwokerto	Interview guideline Validation sheet
The use of learning media in small-scale test and large-scale test	Assessment of test and observation of critical thinking ability	Observation sheet and evaluation test
The assessment of product effectiveness	Response questionnaire for students, teacher, and experts	Questionnaire sheets on the use of interactive learning media

## RESULTS AND DISCUSSION

This R & D research results are presented in the following data:

### The Validation Result of Test Item Trial

**Table 2.** The Validation Result of Test Item Trial

Validation	Number of Test Item	Total of
Valid	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28,	48
Invalid	23, 36	2
Total		50

### The Result of Item Difficulty Trial

**Table 3.** The Result of Item Difficulty Trial

Difficulty Level	Number of Test Item	Total of Test Item
Easy	15, 32, 48	3
Moderate	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49, 50	45
Hard	16, 28	2
Total		50

### The Result of Item Distraction Trial

**Table 4.** The Result of Item Distraction Trial

Distraction Level	Number of Test Item	Total of Test Item
Excellent	3, 47, 49	3
Good	11, 13, 25, 26, 30, 41, 50	7
Adequate	1, 2, 5, 6, 7, 8, 9, 14, 15, 16, 18, 19, 24, 27, 31, 32, 33, 35, 37, 38, 39, 40, 42, 43, 44, 45, 46, 48	28
Bad	4, 10, 12, 17, 20, 21, 22, 28, 29, 34	10
Very Bad	23, 36	2
Total		50

From the overall analysis of the above trial test items then the number of test items that can be used for the next test is 48 test items. All these numbers will be used for trials using CBG games, the number of test items mentioned are the test items number 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, and 50.

### The Result of CBG Implementation/Making

This study has developed CBG learning media and instruments as a means for testing the validity and effectiveness of the media. Learning sets resulted from development include syllabus, lesson plan, android based educational game (hereinafter referred to as CBG), game developed

with inquiry approach and critical thinking.

### The Development of Carbonil Board Game (CBG)/AI Chemist Knight

The next process is to do the programming or coding so as to create the finished form of the product in the form of educational game. An overview of the design and appearance can be seen on the story board in the attachment. The game is a computer game created with the help of Adobe Flash CS6 software with action script 3.0 language. This game can run well on computers with minimum specifications Intel® Pentium® 1.6 GHz processor, 1024MB memory, equipped with sound card and VGA graphic card. Games can run under the operating system of Windows me, XP, Vista, Windows 7, Windows 8 and Android. For the android operating system, it has to go through the installation process of the file android installer (apk).

The material content developed in the game is the alkane derived compound material for class XII of senior high school. This material is divided into several subs which are included in stage game. The game consists of two stages and each stage consists of 2 settings. The initial display design (main page) of the game can be seen in Figure 1.

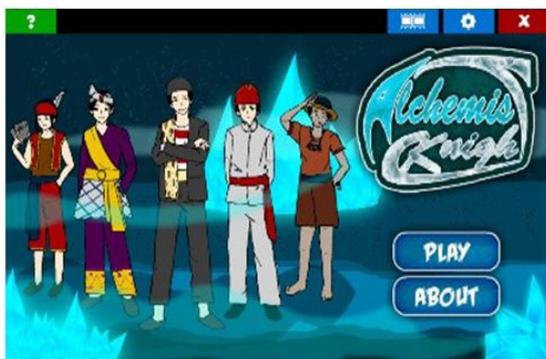


Figure 1. The Starting Appearance of the Game

The game called Chemistry Board Game or AI Chemist Knight is an educational game in the form of board game. On this board the learners will get the material and practicum as well as exercise questions that are appropriate with the material. Learners win the game if they have makee a straight/vertical/horizontal line on the board and they create at least three interconnected lines. This is the rule of the game to be followed. Game board images are presented in Figure



Figure 2. The Game Board of Chemistry Board Game / AI Chemist Knight

### The Result of Validation and Revision towards the Learning Set

Telah disampaikan bahwa perangkat yang dikembangkan meliputi silabus, RPP, dan *educational game* serta LKS yang berbasis inkuiri dan berfikir kritis. Hasil validasi perangkat pembelajaran oleh beberapa validator disajikan dalam Table 5. It has been stated that the learning sets developed include syllabus, lesson plan, and educational game and student's worksheet which are based on inquiry and critical thinking. The validation results of the learning sets by some validators are presented in Table 5.

Table 5. The Validation Analysis Sheet of Media and Learning Sets

Instrument of The study	Assessment Average in Percentage (%)
Syllabus Validation	83.33
Lesson Plan Validation	83.33
Game Validation (material)	78.33
Game Validation (language)	83.33
Game Validation (learning design)	84.25
Game Validation (software engineering)	79.16
Game Validation (visual communication design)	80
The validation average of media and learning sets	81.67

Table 5 shows the average validation score of the experts with percentage of 81.67%. The score indicates that the assessment from the ex-

perts has valid criteria, so it can be concluded that the research instrument can be used as a means of data collection in research.

Educational game testing was done by material validators to analyze the content of chemistry material. Validation results show that CBG chemistry materials are adapted to the 2013 curriculum by using a scientific approach in the learning and taking contextual examples in the students' life so that the students' inquiry and critical thinking skills will increase. The validation result is a summary of the three validators and the recapitulation result of the substance of the material listed in Table 5.

**Table 6.** The Recapitulation Result of The Material Substance Validation

Assessment Aspect of Educational Game	Average Score of The Three Validators	Category
Feasibility of content/material	3.27	Very valid
Language of the material	3.33	Very valid
Learning design	3.37	Very valid
Visual communication design	3.2	Very valid

### Critical Thinking Ability

One of the goals of science learning is developing students' critical thinking skills (Bailin, 2002). The following table shows the average score of critical thinking skills in the experimental class.

**Table 7.** The Average Score of Critical Thinking Ability in the Experimental Class

Aspect	Average score	Criteria
Focusing the questions	3.1	Good
Analyzing arguments	2.95	Good
Asking and answering questions	3.0	Good
Determining actions	3.05	Good
Indicator average	3.025	Good

From the data, it is known that inquiry learning using CBG game and student's worksheet aided will develop students' critical thinking ability on a good scale in terms of four indicators of critical thinking ability, ie focusing questions, analyzing arguments, asking questions and answering questions, determining an action. Among the four indicators, learners have a balanced ability which is evidenced by the difference in scores between indicators that are not much different (Liliasari, 2003).

### Discussion

#### The Development of CBG Media

The development of learning program is a matter that is necessary especially in class XII chemistry material. With the limited time of class XII and the material is a lot and abstract, it is necessary to develop game media that will help learners' understanding. Based on the interviews, it is known that the needs of teachers and students of SMA-IT Al Irsyad is the development of media. By looking at the habits of learners in using their free time in which they more often play games on their android phone, then the researchers developed educational games that are expected to help the understanding of learners in alkane derived compound material.

CBG is a computer game that can now be used in learning. By using CBG with inquiry approach, it will improve learners' critical thinking skills. CBG development by utilizing adobe flash CS6 allows learners to learn wherever and whenever. CBG with features equipped with materials, exercise questions and practicum animation will deepen the concept of learners about alkane derived compound material. In line with the research (Jagodzin'ski & Jagodzin'ski, 2015) stated that the virtual experimental assessment model has been developed by utilizing NUI technology, kinetic sensor technology used in android based smartphones, the application of practicum assessment using NUI will provide motivation to learn and deepen understanding of learners on the chemistry practicum competence.

In this research the development of CBG is developed in an effort to give understanding of cultural and character education and train the students in the ability of creative thinking. The learning sets developed in addition to CBG are syllabus and lesson plan. All the completeness of the set is made with the aim to improve learning outcomes of learners and foster the values of the nation's character that includes creative, curiosity, independent and honest.

Learning set that will be used in the previous data collection is validated by the validators based on the assessment then the average score above 3 or if it is stated in percentage will be more than 70%. The figure indicates that the developed instrument is valid although there are some that need to be revised or developed further.

The development of syllabus and lesson plan in this research focuses on the application of inquiry characterized media and applying critical thinking indicator, applied to chemistry learning process of alkane derived compound material, the material is visualized in the form of game level which must be completed by the students. The results show CBG games can increase the enthusiasm of learners in studying chemistry. Good enthusiasm correlates with the increased learning outcomes of learners' cognition. Learners can be motivated to complete the game in line with improving their understanding of the alkane derived compound material. After completing the game, learners get reward from the teacher. In addition to rewards, another positive thing that learners get is that they volunteered to learn to understand the material. A good understanding of alkane derived compound material then correlates with the ability of learners in solving posttest test items.

In addition to the enthusiasm of learners, another thing that stands out during the research is the emergence of motivation to compete. In line with the opinion of (Toprac, 2008) which states that the motivation of learners can increase with the educational game, this research also raises the spirit of competing well among the students. They learn and strive to be the fastest in completing educational games. The advantage for teachers is that learners do not need to be reminded to study chemistry. Chemistry becomes something fun because learners can learn chemistry while playing games just like an online game.

### **The Effect of CBG Media Development Learning Completeness**

Learning completeness is measured by using the pretest given at the beginning of the research and posttest provided at the end of the study. The success of the class can be seen from at least 85% of the number of students in the class who has reached the completeness of the individual (Mulyana, 2004). From the calculation results, it was obtained learning completeness of 85%, while the completeness before treatment of 5%, with the increase in n-gain 0.703 in the high category.

The existence of students' learning completeness can be defined that CBG game was de-

veloped effectively and successfully. Actually, many factors affect the learning outcomes. One of them is the learning strategy that is pursued in the presentation of teaching and learning process. Presentation of games leads learners to be more interactive and fun so they can build their own knowledge. This can increase the ability of students to master the concepts they learn. In accordance with the statement of (Komalasari, 2010), learners need interactive activities to improve their motivation and effectiveness of their learning.

In addition to learning completeness, from the results of the posttest score, it also shows the enhancement mastery of the concept of alkane derived compound material. From the test results, it is known that the pretest score of 34.35 and posttest score of 80.51. Significant score increases indicate that CBG media or games are able to clarify alkane derived material and improve student's learning achievement.

The increase in student's score by using android games is in line with the results of research by (Jagodzin'ski, 2015) which states that the use of kinetic sensor based virtual laboratory in chemistry practicum will improve student's learning outcomes and foster self-confidence in practicum in the laboratory. Meanwhile (Akhlis & Dewi, 2014) has created an inquiry-based learning set by using ICT (e-learning) to develop student's character, the research results prove significant influence on the student's character by using e-learning ICT.

The use of CBG games in learning is done with inquiry approach which is embodied in the CBG game stage. At each level learners are presented with a problem then learners must complete it in order to reach the stage board game al chemist. When the learner stage has reached al chemist then learners should solve the problem in the box of al chemist available where in the box presented a problem and its solution. This corresponds to the inquiry stage which is the phase of formulating the hypothesis, testing the hypothesis and drawing conclusions (Klisch et al., 2012) stated in his journal report that learning with inquiry setting on a virtual laboratory game enhances student's knowledge and literacy of the science regarding the pollutants that enter the body by inhalation.

Meanwhile, learning with inquiry setting will stimulate learners to develop their critical thinking ability. Measurement of critical thinking ability of learners is done by making observations during learning by using CBG. Indicator of critical thinking is used on the problem created for

CBG games. Therefore, when students play the CBG/Al Chemist game, their critical thinking skills will increase, this is due to the integration of critical thinking indicators with the game problem. Indicators used include the ability to focus the questions, analyze arguments, ask questions and answer questions, and determine an action.

The use of respiratory module by applying critical thinking indicator proved to be effective in improving student's learning outcomes (Khasanah et al., 2017). Adnan et al. (2017) stated that the use of Bana Game in junior high school students in Situbondo was able to improve students' critical thinking skills. Critical thinking, problem solving and analysis skills of middle school students increased by using inquiry based learning in the provision of organic pharmaceutical-based chemical based projects (Weaver, 2016). The results of Hairida (2016) stated that inquiry-based learning modules with authentic assessment on additive materials was proven to be effective to improve student's inquiry ability and critical thinking skills. While Cahyani et al. (2014) stated that multimedia-based inquiry learning simply improves students' cognitive ability with N Gain achievement of 0.31.

### CONCLUSION

According to the results and discussion, the researchers draw some conclusions as follows: The validity test towards the android based CBG games interactive media on the alkane derived compound material results in very valid category for all tests including material feasibility, language, visual communication design, and learning design, each of them gain the score of 3.27, 3.33, 3.2, and 3.37.

CBG games media improves learners' critical thinking skills on the effective category which is proven through the observations which show scale of three or good category. This category consists of 4 aspects of learners' critical thinking skills which include focusing questions, analyzing arguments, asking and answering questions, and determining actions.

CBG games media can improve learners' conceptual understanding especially on the alkane derived compound material. After using CBG, students got better score. In pretest, students got

the average score of 34.35 and the learning completeness of 5%, while in posttest they got the average score of 80.51 and learning completeness of 85%. In addition, the N-gain factor value reaches 0.703 in the high category.

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## IDENTIFICATION OF CHEMISTRY LEARNING PROBLEMS VIEWED FROM CONCEPTUAL CHANGE MODEL

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### ABSTRACT

This study aimed at describing and explaining chemistry learning problems viewed from conceptual change model and misconceptions of students. The study was qualitative research of case study type conducted in one class of SMAN 1 Singaraja. Subjects of the study were a chemistry teacher and students. Data were obtained through classroom observation, interviews, and conception tests. The chemistry learning problems were grouped based on aspects of necessity, intelligibility, plausibility, and fruitfulness. Data were analyzed descriptively. The results of the study showed that the chemistry learning problems related to the aspect of necessity were that the teacher did not carry out the laboratory work and did not discuss the properties of the buffer solution. The problems related to aspects of intelligibility were the teacher asked successive questions, answered her own questions, gave wrong information, made unclear and wrong analogies, and did not ask student reasons. The problems related to the plausibility aspects were that the teacher had less emphasis on the importance of context and neglected the students' alternative conceptions. The problems related to the fruitfulness aspects were that the teacher was less likely to provide complex problems especially with regard to the application of the buffer solution in everyday life. Students experienced misconceptions on some concepts of buffer solution.

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**Keywords:** conceptual change model; misconceptions; buffer solution

### INTRODUCTION

The learning process occurs continuously during the learning process takes places in accordance with the view of constructivism. Based on this view, students actively build their own knowledge based on cognitive maturity. The teacher must be aware that knowledge can not be transferred from the teacher's head to the students' head. In the view of constructivism, the understanding of learning emphasizes on the process rather than results. Students construct or build their understanding of natural events/facts encountered by using experiences, cognitive structures, and beliefs in order to gain understanding or knowledge and cultivate reasoning.

Students attend to the classroom are generally not with empty heads, but rather they bring a number of previously established experiences or ideas when they interact with the environment (Pinker, 2003). This means that before the learning activities take place, students have ideas about the events around them. These ideas are called as prior knowledge, preconceptions, or alternative conceptions that will be the basis for building their next knowledge.

In the conditions of cognitive conflict, students are faced with three choices, namely (1) retaining their original intuition (the ability to understand something without reasons, rationality, and intellect); (2) revising some of their intuition through assimilation; and (3) changing their views and accommodating new knowledge (Santyasa, 2008). The prior knowledge of stu-

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dents will turn into scientific concepts only if the teacher's learning becomes more necessary, intelligible, plausible, and fruitful for students (Posner et al., 1982). The conceptual change model is an effective learning model in changing the students' misconceptions into the scientific concepts (Posner et al., 1982; Hewson & Thorley, 1989; Hennessey, 2003; Cetengul & Geban, 2005; Balci et al., 2006; Onder & Geban, 2006; Dilber & Duzgun, 2008; Berber & Sari, 2009; Trundle & Bell, 2009; Gadgil, Nokes-Malach, & Chi, 2011; Aydin, 2012; Kaya & Geban, 2012; Taslıdere, 2013; Madu & Orji, 2015; Tas et al., 2015; Yumusak et al., 2015).

The conceptual change model is a learning model that describes an interaction between new conceptions and pre-existing conceptions. It is widely used in science subjects. This model was first introduced by Posner et al. (1982) and more than a decade of this model has greatly influenced studies in the field of student conceptions.

Recent studies in the field of education begin to focus on the problems of learning. Orgill & Sutherland (2006) state that teachers tend to focus more on the aspects of calculation rather than those of concepts in the learning to explain chemistry subject. This results in students having difficulties in understanding the chemical concepts correctly. Some students' understanding is inconsistent with the views of the scientific community. It is called misconceptions. Students experiencing misconceptions will have difficulties in relating their concepts with the next concepts. Therefore, the teachers must know the misconceptions of students so that they are able to carry out the teaching and learning process in accordance with the prior knowledge of students.

SMA Negeri 1 Singaraja as a part of the educational institution is in charge of preparing graduates who are intelligent, having life skills, cautious to God Almighty, having the noble character, and so on. It is a favorite school in Buleleng regency of Bali. Students' academic achievements in the event of such olympic competitions are quite proud. Likewise, the number of graduates of SMA Negeri 1 Singaraja received at the favorite colleges is quite a lot. However, the results of observations on the chemistry learning showed that chemistry the teachers applied traditional learning. In this traditional learning, the chemistry teachers used more lecture and question and answer methods as well as group discussions. Observation results also showed that some chemistry teachers provided many tasks to the students so that they were able to solve problems given by the teachers. Given these tasks, the te-

achers hoped that students actively learnt. This actually caused students to experience difficulties due to lack of guidance from the teachers.

The study aimed at describing and explaining the problems of chemistry learning conducted by the chemistry teacher on buffer solution in terms of the conceptual change model of Posner et al. (1982). The study results of Orgill & Sutherland (2006) found that students experienced misconceptions on the topic of buffer solution. Students considered that the stronger the acids and bases form a buffer solution, the greater the capacities of the buffer solution are. In addition, students were convinced that the buffer solution could be made from mixtures of acids and bases regardless of acid or base strength. The teacher-centered teaching that emphasizes the calculation aspects enables low comprehension and misconceptions among students. de Jong et al. (1995) reported that, in fact, the chemistry teachers who taught redox reactions had a lot of learning problems related to the conceptual change model. These learning problems included they presented the unsuitable problems, presented the unnecessary explanations, explained the conceptions prematurely, used the confusing terms, taught the less context, ignored the alternative conceptions of students, discussed the less application of concepts (especially in industry), and explained too many procedures from experts. Based on these descriptions, the studies on the problems of chemistry learning on other concepts were very important to do.

The studies involving the students' misconceptions in relation to the conceptual change model has been reported on the electrochemical concept in the Netherlands (de Jong et al., 1995). These studies were forwarded to other countries, such as the United Kingdom (Bojczuk, 1982), the North America (Finley et al., 1982), and Australia (Butts & Smith, 1981). The studies of the conceptual change model related to the concepts of electrochemistry were reported in the United Kingdom (Allsop & George, 1982), Spanish (Barral et al., 1992), and Australia (Garnett & Treagust, 1992a; 1992b). Meanwhile, Redhana (2011) has investigated the students' misconceptions on the topic of hydrocarbons.

## METHODS

This study was a qualitative research with case study type. The study was conducted at SMAN 1 Singaraja from February to April 2014. The subject of the study was a chemistry teacher and students consisting of 28 people coming

from one class. This case study was done on the buffer solution topic. The focus of the study was the process of teaching and learning and conceptions of students. Data were collected from the learning processes and student's conception through observation, interview, and test. The observations were conducted to the teaching and learning process that took place in the classroom. The observation results, all drawings, and notes on the board either made by the teacher or students were copied into a field notebook. In order for the observations obtained more accurately, the ongoing chemistry learning process was recorded with video and voice recorder.

Results of recording of video and voice recorder were combined and then transcription was made by researchers. After the topic of the buffer solution has been taught, the researchers carried out a conception test to the students. The conception test was made based on the findings of the

problems in the learning process after the transcription was made. This conception test was a two-tier test, which was an objective test with reason. The test consisted of 15 items of questions.

Based on the transcription, the researcher identified the problems of chemistry learning done by the teacher. These problems were grouped into aspects of the conceptual change model of Posner et al. (1982), which included necessity, intelligibility, plausibility, and fruitfulness.

## RESULTS AND DISCUSSION

The results of the study were the problems of chemistry learning viewed from the conceptual change model of Posner et al. (1982) and the students' misconceptions. Data of the problems of chemistry learning were presented in Table 1. As a result of these learning problems, students experienced misconceptions as shown in Table 2.

**Table 1.** The problems of chemistry learning in one class of SMAN 1 Singaraja.

Characteristics of New Conceptions	Descriptions
Necessity	<p>Most materials presented by the teacher were in accordance with the curriculum requirements (content standards: competency standards and basic competencies), such as analyzing buffer and non-buffer solutions through experiments, calculating the pH or pOH of buffer solution, calculating the pH of the buffer solution with the addition of slight acids or bases, or by dilution, and explaining the function of buffer solutions in the body of living things. However, there were some problems of chemistry learning in relation to the aspects of necessity presented as follows.</p> <ol style="list-style-type: none"> <li>1. The teacher did not conduct laboratory work to analyze buffer solutions and non-buffer solution through experiments, but she only presented the experimental data.</li> <li>2. The teacher did not discuss the properties of the buffer solution which was capable of maintaining the pH of the solution if it was diluted. On the other hand, she discussed more the properties of the buffer solution when added by slight acids or bases.</li> <li>3. The teacher did not fully discuss the function of the buffer solution in the living things.</li> </ol>
Intelligibility	<p>Some of the problems of the chemistry learning related to aspects of intelligibility were as follows.</p> <ol style="list-style-type: none"> <li>1. The teachers asked successive questions to students. One question asked by the teacher had not been answered by the students, she asked other questions. This could be seen in the following description. The teacher asked: "What does it mean of conjugation? Who states the concept of the conjugate of acid-base? Why is <math>\text{CH}_3\text{COONa}</math> called the conjugate base? Because of what? Do you remember the Bronsted-Lowry acid-base concept?" The teacher wrote the equilibrium reaction of <math>\text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}^+</math>. She asked: "How is the ion concentration of <math>\text{CH}_3\text{COO}^-</math> if the pH of the solution is increased? What happens to the equilibrium reaction? Who overcome this shortcoming?"</li> <li>2. The teacher answered her own questions. The teacher wrote the reaction of <math>\text{CH}_3\text{COOH}</math> formation of <math>\text{CH}_3\text{COO}^-</math> and <math>\text{H}^+</math> ions. She asked: "If HCl solution is added to the buffer solution, to which the equilibrium shifts?" She then answered her own question: "The shift goes to the formation of <math>\text{CH}_3\text{COOH}</math>." The teacher asked: "Why can not the weak acid of <math>\text{CH}_3\text{COOH}</math> form a buffer solution with the NaCl salt?" She then answered her question: "Because the definition of the buffer solution is a mixture of weak acids and their conjugate bases or between weak bases and their conjugate acids."</li> </ol>

3. The teacher gave wrong information.

The teacher said: "If the buffer solution of  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COO}^-$  is added by the slight bases, then the  $\text{OH}^-$  ions will bind the  $\text{H}^+$  to form  $\text{CH}_3\text{COOH}$ ." Supposedly, the  $\text{OH}^-$  ions bind the  $\text{H}^+$  ions to form  $\text{H}_2\text{O}$ .

The teacher described the formation reaction by stating: " $\text{CH}_3\text{COOH}$  molecules were formed from  $\text{CH}_3\text{COO}^-$  ions and  $\text{H}^+$  ions." She mistakenly understood about the formation reaction.

4. The teacher made unclear and wrong analogies.

The teacher explained: "The buffer solution can maintain pH when it is added by the slight acids, the slight bases, or diluted. Still, remember? A bit acid, a bit base." Just like "If you eat excessively, then you can get dizzy. Therefore, you should eat sufficiently." The analogies made by the teacher was not related to the statement described earlier.

5. The teachers did not ask students' reasons.

Students stated: " $\text{CH}_3\text{COOH}$  becomes  $\text{CH}_3\text{COO}^-$  ions by removing and  $\text{CH}_3\text{COO}^-$  ions becomes  $\text{CH}_3\text{COOH}$  by receiving." She did not ask the students' reasons about what was removed and what was received?

The teacher asked: "Is mole or molar used in the pH calculation of buffer solution?" Student answered: "Mol." She did not ask the students why the mole is used in the calculation of pH of buffer solution instead of the molar.

#### Plausibility

1. The teachers did not emphasize the importance of context. This could be seen from less explanation of the teacher about the role of buffer solutions in the living things, which included a blood buffer system and body fluid support system. She did not discuss the working mechanism of buffer solutions in the body.

2. The teacher ignored the students' alternative conceptions.

The teacher asked: "What happens after the  $\text{H}^+$  ions from  $\text{HCl}$  combine with  $\text{CH}_3\text{COO}^-$  ions?" Students replied: "Binding." She did not further explore about "binding."

The teacher asked: "What is the properties of the  $\text{CH}_3\text{COOH}$  solution?" The student replied: "Strong acid." The teacher then explained another topic. The teachers should ask students why the  $\text{CH}_3\text{COOH}$  solution was strongly acidic.

#### Fruitfulness

The teachers were less likely to provide complex problems especially with regard to applications of the concept of buffer solutions in everyday life, such as the use of buffer solutions in the pharmaceutical industry (in the manufacture of drugs).

#### 2. The students' misconceptions on the buffer solution

Based on Table 2, it seemed that there were many problems of chemistry learning which had not met the criteria of conceptual change model of Posner et al. (1982). Even though the conceptual change model of Posner et al. (1982) has long been developed, but the model is still highly relevant to the current and future learning process. This is due to the conceptual change model of Posner et al. (1982) accommodates the theory of scientific revolution of Khun (1970) and the theory of cognitive development of Piaget (Santrock, 2011). In the theory of scientific revolution (Khun, 1970), the old paradigm will be partially or completely replaced by a new paradigm if it is contradictory. On the other hand, in Piaget's cognitive development theory, students must change their schemes if the new knowledge being studied does not match to the pre-existing scheme. This process is called the accommodation according to Piaget.

Based on the transcription of learning that has been made, it appeared that the learning that took place was centered on the students. The teach-

er provided more information or transfer knowledge to students. The chemistry learning problems being found were as follows. Firstly, from the aspect of necessity, the teacher did not conduct chemistry laboratory work to study the properties of the buffer solution, but she only presented the hypothetical experimental data. Although such learning was not entirely wrong, but students could not directly observe the natural phenomena associated with the properties of the buffer solution. Likewise, students did not have the opportunity to develop skills, especially the skills of using laboratory tools.

In addition, aspects of student attitudes that were the nurturing effects of the learning process also could not develop optimally. Sciences including chemistry are developed from the experimental results. The chemistry learning without laboratory work was like history learning. This resulted in low students' memory. Secondly, the teacher did not discuss the properties of the buffer solution if dilution is performed. She discussed the buffer properties more about the effect of the addition of slight acids or bases to pH change. In short, in this necessity aspect, the teacher presented incomplete buffer topic.

**Table 2.** Students' Misconception on Buffer Solution Materials

The Students' Misconceptions
CH <sub>3</sub> COONa is an acidic salt.
HCOONa is an acidic salt.
CH <sub>3</sub> COONa is a weak acid.
CH <sub>3</sub> COOH is a strong acid.
CH <sub>3</sub> COONa is a conjugate acid of NaOH.
A mixture of weak acids with salts may form a buffer.
The mixture between HCN and NaCl forms a buffer solution.
Strong acids react with salts to form salt hydrolysis.
The reaction product between NH <sub>4</sub> Cl and KOH is KNH <sub>4</sub> .
If the buffer solution is mixed with a strong acid or strong base solution, the mixture can still maintain the pH.
The buffer solution is formed of acids and weak bases.
NaCl is a salt without pH.
Buffer solutions can be formed from weak acids and salts.
The chemical formula of nitric acid is NHO <sub>2</sub> .
The chemical formula of cyanide acid is HNCN.
If the buffer solution is added by acids or bases, pH will not change.
The buffer solution is a solution whose pH does not easily change if it is dropped gradually with acids, or bases, or was diluted with water even in large quantities.
In the buffer solution, the remaining is strong bases so that the buffer solution is alkaline.
The reaction between acetic acid and barium hydroxide is $2\text{CH}_3\text{COOH} + \text{Ba}(\text{OH})_2 \rightarrow 2\text{CH}_3\text{COOBa} + 2\text{H}_2\text{O}$ .

The chemistry learning problems related to the aspect of intelligibility are as follows. Firstly, the teacher asked successive questions to students. Asking questions is important, but students should be given the opportunity to think about the answers of the questions. Students had not answered the first question, even still thinking, the teacher directly asked the students with the next question. This could be seen from the following transcription of learning. The teacher asked: "Remember what does it mean by conjugation? Who declares the concept of conjugate acid-base? Why is CH<sub>3</sub>COONa called the conjugate base? Because of what? Do you remember the acid-base concept of Bronsted-Lowry?" This condition could lead to students becoming frustrated in learning chemistry.

In addition, the teacher mistakenly stated that CH<sub>3</sub>COONa salt was a conjugate base. Secondly, the teacher answered his own question. This could be seen from the following transcription of learning. She wrote the formation reaction of CH<sub>3</sub>COOH from CH<sub>3</sub>COO<sup>-</sup> ions and H<sup>+</sup> ions. She then asked: "If the HCl solution is added to the buffer solution, to which the equilibrium shifts?" She then answered her own question: "The shift goes to the formation of CH<sub>3</sub>COOH." Consequently, students were inactive learners. In other words, the teacher was too active in the learning. Thus, the constructivist learning

paradigm that expects students to actively construct knowledge can not take place. Thirdly, the teacher gave wrong information. This could be seen from the following transcription of learning. She said: "If slight bases are added to the buffer solution of CH<sub>3</sub>COOH and CH<sub>3</sub>COO<sup>-</sup>, the OH<sup>-</sup> ions will bind the H<sup>+</sup> ions to form CH<sub>3</sub>COOH." Supposedly, the OH<sup>-</sup> ions bind the H<sup>+</sup> ions to form H<sub>2</sub>O. Misinformation submitted by the teacher to the students could cause the students to misunderstand the concepts being studied. In other words, students experienced misconceptions. This meant that teachers could be a source of misconceptions for students.

Fourthly, the teacher made an unclear and wrong analogies. This could be seen in the teacher's explanation as follows. She explained: "The buffer solution can maintain pH if it is added by slight acids, slight bases or diluted. Still, remember? A bit acids, a bit bases. Just like "If you eat excessively, then you can get dizzy. Therefore, you should eat sufficiently." The analogies made by the teacher was not related to the statement described earlier. The unclear and wrong analogies could mislead students. Fifthly, the teacher did not ask the students' reasons. This could be seen from the following transcription of learning. The teacher asked: "Is mole or molar is used in pH calculation of buffer solution?" Students answered: "Mol." She did not ask the student why mol is

used in pH calculation of buffer solution instead of the molar. She did not explore further the students' answers what reasoning is. If this was allowed, they would not know which concept is correct.

The chemistry learning problems related to aspects of plausibility were as follows. Firstly, the teacher did not emphasize the importance of context. This could be seen from teacher's explanation. She discussed the less role of buffer solutions in living things, which included blood buffer systems and body fluid support systems, and the application of buffer solutions in everyday life. This could result in students not knowing the link between the concepts being studied and their application in everyday life. Students felt the concepts they were learning were useless to their life. The importance of linking the concepts learnt with their application in everyday life has been the goal of sciences lately because sciences including chemistry have a high application in everyday life. Therefore, the contextual teaching and learning is a teaching and learning that is suitable to teach science, including chemistry (Brist, 2012). Secondly, teacher ignored the alternative conceptions of students. This could be seen from the transcription of learning as follows. She asked: "What is the properties of the  $\text{CH}_3\text{COOH}$  solution?" The students answered: "Strong acid." She should ask students why the  $\text{CH}_3\text{COOH}$  solution is the strong acid. Before learning, students actually have had a number of conceptions. This alternative conception should be considered by the teachers in designing learning strategies that will be applied. Likewise, any alternative conceptions that arise during the learning processes should be of concern to teachers. If they are misconceptions, then she must turn them into scientific conceptions.

The problems of chemistry learning related to the fruitfulness aspect were that teacher did not provide complex problems especially those related to the application of buffer solution in everyday life. The complex problems are ill-structured and open-ended problems and contextual issues. Solving these problems requires higher-order thinking. The higher-order thinking was the goal of all educational curricula. The description above showed that the ongoing learning was the teacher-centered teaching. This kind of teaching failed to improve students' understanding of the concepts being studied. Even the results of this study indicated that the teaching applied by the teacher was not able to make changes to the conceptions of students significantly. This was apparent from the students' misconceptions of the buffer solution. Generally, students experiencing misconceptions may be caused by associative thinking, incomplete or incorrect reasoning, wrong experiences, and conclusions based on what appears on

the surface only (Kurniawan, 2012). It could be said that students did not understand the concept completely. The incomplete reasoning of students was caused by incomplete information or data. As a result, students drew a wrong conclusion and this could lead to misconceptions. The findings above were in line with previous study findings. The results of the study showed that teachers who taught hydrocarbon concepts have a lot of learning problems in terms of conceptual change models (Redhana, 2011). These learning problems included presenting erroneous questions, presenting less structured information, providing incomplete information, misinformation, and making unclear analogies.

The results of the study above confirmed previous findings related to misconceptions (de Jong, 1982; de Jong et al., 1995; Nahum, Hofstein, Mamlok-Naaman, & Bar-Dove, 2004; Chiu, 2005; Barke, Hazari, & Yitbarek, 2009). The students' misconceptions were found on almost all chemistry topics, such as atomic structures, periodic systems, and chemical bonds (Redhana & Kirna, 2004). Meanwhile, (Bannerjee, 1991) found the students' misconceptions on the chemical equilibrium topics, namely: (1) rainwater was neutral; (2) for the same concentration, the pH of acetic acid solution was less than or equal to the pH of the hydrochloric acid solution; and (3) there was no hydrogen ions in the sodium hydroxide solution. Ross & Munby (1991) reported the students' misconceptions on acid-base topics, namely: (1) all acids were strong acids; (2) combustible substances were acids; (3) all acids were toxic; (4) fruits were alkaline; (5) strong acids contained more hydrogen bonds than weak acids; (6) all sharp-smelling substances were acids; (7) acids were bitter and spicy; and (8) the soil might not be acidic because something was impossible to grow in acids. Bradley and Mosimege (1998) reported the students' misconceptions on the topics of acids and bases, namely: (1) all salt solutions were neutral; (2) indicators were used to test whether a substance was a strong or weak acids; and (3) an indicator neutralized the acidity of the solution. On the other hand, Redhana (2011) reported the students' misconceptions on the topics of hydrocarbons, including: (1) isomers of hydrocarbon compounds had different relative masses; (2) isomers of hydrocarbon compounds had similar physical and chemical properties; (3) in molecules ethene, one C atom was positively charged and another C atom was negatively charged; (4) the most volatile compounds were compounds having the highest boiling point and the highest molar mass; (5) in a methane molecule, all hydrogen atoms were positively charged; (6) in the  $\text{Cl}_2$  molecule, one Cl atom was more positively charged and another Cl atom was more negatively charged; (7) at the substitution reaction of methane

by HCl, the H atoms of methane could be replaced by the H atom of HCl because the H atom of HCl had higher degree; (8) gasoline was explosive and flammable because it had a high boiling point; (9) a branched carbon skeleton was more easily broken down by microorganisms than that of a straight carbon; and (10) air crafts used kerosene fuel. Khasanah et al. (2016) reported that students' misconceptions generally occurred in low mental models. Mental models can be grouped into three categories, namely low, medium, and high mental models.

Teachers need to devise the conceptual change strategies to remediate students' misconceptions. The various conceptual change strategies have been developed to remediate student misconceptions, including: (1) the conceptual change texts (Tsai & Chou, 2002; Cetengul & Geban, 2005; Onder & Geban, 2006; Balci et al., 2006; Berber & Sari, 2009; Sinatra & Broughton, 2011; Aydin, 2012); (2) the web-based conceptual change texts (Calik et al., 2011; Tas et al., 2015); (3) the computer simulations (Trundle & Bell, 2009); (4) the computer-based learning (Kose, Kaya, Gezer, & Kara, 2011; Yumusak et al., 2015); (5) ECIRR model (Elicit, Confront, Identify, Resolve, and Reinforce) (Wenning, 2008); (6) the cognitive conflict learning strategies (Baser, 2006; Madu & Orji, 2015); (7) the conceptual change-oriented learning (Baser, 2006; Kaya & Geban, 2012; Taslidere, 2013); (8) analogies (Dilber & Duzgun, 2008); (9) the holistic mental model confrontation (Calik et al., 2011); (10) problem posing (Rufaida & Sujiono, 2013), and (11) multiple representations (Widarti et al., 2016).

## CONCLUSION

The identification of chemistry learning problems is very important. By knowing the learning problems that arise, the chemistry teacher can design the effective learning strategies. The chemistry learning problems viewed from the conceptual change model of Posner et al. (1982) were as follow. The chemistry learning problems that related to the necessity aspects included: (1) the teacher presented incomplete concepts; (2) the teacher did not discuss the properties of the buffer solution; and (3) the teacher did not discuss completely the function of the buffer solution in the living things. The chemistry learning problems that related to aspects of intelligibility included: (1) the teacher asked successive questions; (2) the teacher answered her own questions; (3) the teacher gave wrong information; (4) the teacher made an unclear and wrong analogies; and (5) the teacher did not ask the students' reasons.

The chemistry learning problems that related to plausibility aspects included the teacher did not emphasize the importance of the context and the teacher ignored the alternative conceptions of students. The chemistry learning problems that related to fruitfulness aspects included teacher gave less complex problems in term of the application of the concepts of buffer solutions in everyday life. On the other hand, the misconceptions that were experienced by students included: (a)  $\text{CH}_3\text{COONa}$  was an acidic salt; (b)  $\text{CH}_3\text{COOH}$  was a strong acid; (c)  $\text{CH}_3\text{COONa}$  was the conjugate acid of NaOH; (d) the mixture of HCN and NaCl formed the buffer solution; (e) NaCl was the salt without pH; (f) the buffer solution might be formed from weak acids and salts; and (g) the buffer solution was the solution having the unchanged pH even though it was dropped by slight acids, slight bases, or was diluted with water even in large quantities.

Based on the results of the study it could be suggested that the teachers, especially problems related to the students' misconceptions. They can design effective lesson plans to improve students' understanding toward the chemistry concepts learnt and to remediate the students' misconceptions.

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## PROJECT-BASED LEARNING DESIGN FOR INTERNALIZATION OF ENVIRONMENTAL LITERACY WITH ISLAMIC VALUE

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### ABSTRACT

This research aims to produce teaching and learning design to develop environmental literacy among students through project-based learning to internalize the Islamic values. The program was developed through research and development design with three phases: a preliminary study, development program, and feasibility studies. This research produces three characteristics of the teaching and learning programs i.e.: (a) Developing environmental literacy of students based on Islamic values by using project-based teaching and learning; b) Developing the main themes of 'Green Living' of which is divided into four sub-themes: 'Save our water,' 'Save our Soil,' 'Use Eco-friendly Products' and 'Waste for Life'; c) Facilitating students to conduct learning activities, in order to develop scientific skills and environmental literacy. The design model was validated by experts' judgment. The tests showed that this design is feasible to be used in courses. It is suggested that the theme be broadened to include other relevant themes with environmental issues. The study is recommended to be followed up with testing and implementation by integrating the themes in other relevant subjects.

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**Keywords:** environmental literacy; internalization of islamic values; project-based learning

### INTRODUCTION

The environment provides natural resources to sustain our life. God creates this nature which consists of human and the environment in a balance and harmony (Harahap, 2015). This natural resource needs human wisdom to manage it. There are more than 750 verses in the Quran that are related to nature. It is said that nature is indeed a bounty of God (Allah) that makes the humanity and all other living organisms survive in the earth (Ashtankar, 2016). Protecting the environment from all kinds of detriments and preserving the nature is the philosophy of Islamic en-

vironmentalism. This is humans duty to take care of environmental sustainability (Islam, 2004). Humans are obliged to manage and protect the balance of the ecosystem in order to prevent it from degradation and destruction (Primyastanto et al., 2010). Humans' obligation to conserve the environment is related to their role and obligation as the vice regent (khalifah) in this earth (Ashtankar, 2016).

However, in reality, the environment globally continues to change and deteriorate. The increasing number of the human population leads to the increasing need of food, clothes, and land (Forsyth, 2011). This increasing need has resulted in the reduction of a forest as a place to absorb water. Various flora and fauna extinguish (Hunter, 2007). The use of fossil fuel for diverse needs

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has affected broad environmental impacts such as air pollution, acid rain and the increasing concentration of greenhouse gases which resulted in the global warming phenomena (Anthes et al., 2006).

The environmental problem arises because of too much use of this natural resource (Gayford, 2002). Human activities are regarded to be the most dominant factor in causing environmental degradation (Nahdi & Ghufro, 2006). Due to human beings' selfish attitude towards the environment, the balance, coordination and harmony of the universe have all been negatively affected.

The awareness to manage environment should be cultivated among each. Each has to protect, conserve the environment and to anticipate the impact of environmental destruction (Hamdi, 2015). For this, environmental literacy is needed to create the environmentally sound society which is aware of the meaning of ecology and environment for the sustainable life of human beings (McBride et al., 2013).

Environmental literacy is one of the actualizations of the internalization of Islamic values within Muslim personal. The society who has environmental literacy is characterized by their concern for the environment (Clair, 2003). The concern can be seen from the way of thinking, behaving, and acting to the environment (Goldman et al., 2006). This character is greatly related to the values of human behavior which is related to God (Allah), one's self, among human beings, environment and the nation (Desfandi, 2015).

The internalization of environmental literacy as part of the internalization of Islamic values becomes the key to the sustainability of environmental conservation. Therefore, environmental literacy is very important to be developed among students. The student teachers are very potential to create good environment because they will be the agent of change in the society. Student teachers have to pass on good values and characters in order their students are able to conserve the sustainability of the environment.

Based on the initial study in Math and Natural Science Department, Faculty of Education and Teaching UIN Sunan Gunung Djati Bandung, the subject that relates to the effort of developing students' environmental literacy is of Environmental Knowledge subject. The implementation of the teaching and learning method of this subject tends to be dominated by lecture, discussion, and recitation. Students are not yet facilitated to do the actual action to explore their ability. Especially, there is no evaluation yet to measure students' skills and attitudes in environ-

mental literacy because the existing evaluation still uses written examination that measures cognitive ability.

Based on the interview with the lecturer, the four problems regarding the development of students' environmental literacy areas follows. First, the need to deepen the material of this subject is not balanced with the available time. Second, there is a difficulty in developing the standard of teaching model which is suitable with the existing need. Third, there is a need to develop an appropriate strategy in order that the teaching objective is not limited to cognitive aspect but includes skill and behavior. Fourth, there is a contrast between the knowledge that students have and their daily attitudes and behavior toward the environment. The change of the curriculum which currently refers to Indonesian National Qualification Frames/KKNI (Kerangka Kualifikasi Nasional Indonesia) also requires change in the learning outcome of subject matter. The changes are also associated with the contents of the subject, the number of credit semester, the standard of content and process stated in the curriculum. So a new pattern of lectures is needed.

The content of environmental knowledge is integrated with the development of environmental literacy containing Islamic values in the relevant lectures according to the availability of time and the existing needs in the field. Internalization of environmental literacy with Islamic values requires appropriate approaches and strategies, so that the student learning experience is useful for developing high-level thinking skills, creativity, attitudes and values (Tuncer et al., 2009).

Regarding this, we need an appropriate approach and strategy by adopting project-based learning (PBL) as stated by Thomas (2000). Learning Steps on PBL are focused on questions or problems that drive students to encounter the central concepts and principles of a discipline. The projects involve students in a constructive investigation. An investigation is a goal-directed process that involves inquiry, problem solving, knowledge building, critical and creative thinking (Barak & Dori, 2005). In the learning process, students are engaged as active participants, setting their own learning goals and forging meaningful relations through their experiences, as they investigate real-world issues (Krajcik & Blumenfeld, 2006). Based on the ideas, this study aims to develop a learning design for the internalization of environmental literacy with Islamic values using project-based learning strategies.

## METHODS

This research uses Research and Development Design adapted from Gall, Borg, & Gall, (2003). The results of design development consist of (1) initial study to analyze the need and the relevant materials to develop environmental literacy and (2) based on the initial study, research is conducted to develop project activity design for teaching and learning. In this phase, it is designed: (a) the description of the project-based activities to develop environmental literacy for the student teachers; (b) project-based work sheet for the selected topics; (c) assessment tools to measure the ability of the students' environmental literacy. After that, the design and the instruments are properly tested.

The proper test is undertaken by validating the content conducted by three expert validators. The content validation is undertaken to the teaching and learning design, worksheet, assessment rubric and environmental literacy questionnaire. For this validation, the validators are asked to give feedbacks and comments for revision by filling up the validation sheet. The given answers for validation use the following scale: relevant=3; lack of relevant=2; and not relevant=1. If their answers lack relevance and irrelevance, the validators are asked to give comments for revision.

## RESULTS AND DISCUSSION

The focus of the content to develop environmental literacy with Islamic Values is packed by combining the basic content of Science and everyday environmental issues in one theme of

the project-based learning. The development of this theme should consider its easiness to be applied, its interestingness and usefulness to be stimulated in the teaching and learning.

The packaging in the teaching and learning adopts the project-based learning which aims for the students to develop various basic skills (scientific works skill), thinking skill, the skill to make a decision, the creative abilities and the abilities to solve the problem (Thomas, 2000). By using this approach, the students could produce the product of thinking and the realization of activities which contribute to the improvement of the environment.

The theme 'Green Living' is developed to give knowledge, to foster awareness and to build behavior and values in order the students can conserve the sustainability and the balance of the environment. The essence of 'Green Living' is related to the effort to hold the rate of change in the global climate or the global warming (Rinkesh, 2009). After the teaching and learning process, the student teachers are expected to change their attitudes and behaviour, especially because the life style of 'Green Living' is following the life style of the Prophet Muhammad ('peace and blessing be upon him'). The statement was reinforced by Manoiu et al. (2016) that the Prophet Muhammad ('peace and blessing be upon him') could be considered a pioneer of environmentalism, preservation, sustainable development and resource management. The result of the analysis of the main theme 'Green Living' to develop environmental literacy for each sub-theme can be seen in Table 1.

**Table 1.** The Development of Environmental Literacy in The Theme 'Green Living'

No	Sub Theme	Aims	Main Activities	Environmental Literacy
1	'Save our Water'	To analyze the relation between the water cycle in the earth and the act of saving water To design the trial on how to use detergent wisely To design the project of simple water purification	Analysis of the relation between the water cycle in the earth and the act of saving water The use of detergent wisely Simple water purification (lab scale)	Knowledge about water cycle, attitudes in using water, behavior in using water and skill to do trial in using detergent wisely and skill to purify water (lab scale)
2	'Save our Soil'	To design the trial on how to conserve soil To design the project on how to improve absorption capacity of soil against water	Trial of conserving soil Making bio-pore	Knowledge about the importance of soil conservation, attitudes towards soil conservation and skill in doing trial of conserving soil and making bio-pore

No	Sub Theme	Aims	Main Activities	Environmental Literacy
3	'Use eco-friendly product'	To identify eco-friendly product To design eco-friendly product for the media of teaching and learning Natural Science	The choice of eco-friendly product Making teaching and learning media from eco-friendly product	Knowledge about the importance of using eco-friendly product, attitudes in applying the use of eco-friendly product, the skill to make teaching and learning media from eco-friendly product
4	'Waste of life'	To design waste treatment to make compost To design pilot project to make biogas	Making compost Making biogas (lab scale)	Knowledge about waste for life, attitudes in waste treatment, skill to treat waste

The students are firstly provided an explanation about the issue of global warming. This preliminary stage is intended to raise awareness of students about the importance of all the learning activities in each sub-theme. Students activities in the introductory teaching and learning are as follows: (1) observing and writing the important issues related to global warming through video; (2) Discussing about 'Why global warming is happening? What are the impacts of global warming? What can be done to deal with global warming?'; (3) Assisted by discussion process, the students are asked to read about global warming; (4) The result of the discussion is written in a report and is presented.

In the sub-theme of 'Save our Water,' the students are asked to analyze the relation between water cycle and the act of saving water. Through this activity, it is expected to raise their awareness to save water. The students are also asked to analyze the need for water used in daily life as part of self-reflection.

Saving water is an act modeled by the Prophet Muhammad ('Peace and blessing be upon him'). One of the most striking Hadith (The prophetic tradition as it is narrated by the most authoritative sources) relates to the rejection of the excessive use of commodities, some of which may be directly taken from an over-abundant nature (Islam, 2004). In Islam, it is required that before prayer, the faithful must ablution (wash a part of body i.e. mouth, nostrils, face, arms, head, and feet). The Prophet urged moderation and thriftiness in the use of water during ablution. He had ablution with only one mud of water (one mud is equivalent with one cistern of both adult hands). He warned that each step of ablution should not be performed more than three times even if water supplies were abundant. He warned: "Whoever

increases (more than three) he does injustice and wrong" (Islam, 2004). According to some Islamic scholars, this type of behavior has been discouraged, because it would lead to the development of a wasteful outlook towards the gifts of nature. In the light of this Hadith excessive use of world non-renewable resources such as fossil fuels, even by those who can well afford it, is totally out of line with Islamic teaching (Kula, 2001).

In the sub-theme 'Save our Soil,' the students analyze the cause of landslide: the deforestation. Then, they simulate how the impact of the soil slope and the number of trees on the occurrence of a landslide. Through this activity, students develop the skill of inquiry, problem solving and critical thinking to the existing problem. Through active teaching and learning, the students are empowered to gain knowledge and new understanding based on their own experience through various exploration (Sumarni et al., 2016). Raising consciousness about soil conservation is essential to encourage the act of planting trees. The Prophet (peace and blessing be upon him) attached great importance to planting trees, protecting existent ones, planting forests, protecting and improving derelict land (Islam, 2004). He advised that the faithful should protect the fertility of agricultural land by taking every possible step to prevent its impoverishment. The faithful must keep planting trees even to the end of the world (Ashtankar, 2016). Breaking the tree trunk and deforesting is prohibited even during the war. Cutting the trees without following the right procedure threatens the sustainable life of earth creatures (Khalid, 2002).

In the sub-theme 'Use Eco-friendly Products', the students' activities are directed to identify eco-friendly products; to differentiate between products and activities which are eco-friendly and

eco-unfriendly. They are asked to look for alternative products and activities other than eco-unfriendly products and activities. It is expected that students have the awareness to use eco-friendly products to support the sustainability and preservation of the environment (Emanuel & Adams, 2011). Besides, it is expected that the students be creative to recycle eco-unfriendly products (such as plastic) to become reusable products.

In the sub-theme 'Waste for life,' the students' activities are directed to process domestic waste which can be easily decomposed by a microorganism to become useful products such as biogas and compost. The experiment work sheet to make biogas and compost is designed for a small scale. This work sheet is developed based on the result of research by Farida et al. (2015). Even though it is a pilot project, it is expected that with this experience to experiment, students can apply this skill when they live in their society.

The two sub themes mentioned above are in accordance with Islamic teachings to maintain cleanliness and preserve the environment (Ashtankar, 2016). Islam has created a bond between faith and cleanliness. The Prophet (peace and blessing be upon him) said: "Faith is some seventy branches, the highest of which is "There is no god but God", and the least is removing obstacles from the path of people, and that shyness is a branch of faith (Ozdemir, 2003). In this context, clearing the path means the removal of material obstacles or solid waste which constitute a kind of pollution. The Prophet (peace and blessings be upon him) warned: "Turn away from three forbidden acts: defecating in the water source, in the road-side and under the tree shade" In another Hadith, He said: "Truly that Allah is good who loves kindness, clean and loves cleanliness. Therefore, clean up your yards and never imitate the Jewish" (Khalid, 2002). The prohibition of these two Hadiths is intended to prevent environmental pollution. The direct human polluting activity at the time is extended to indirect sources of pollution, such as through sewers. The natural pollutants of the time are extended to include the chemical pollutants (Islam, 2004).

For each sub-theme, work sheet is developed to be used as students' guide in their teaching and learning process. In general, the work sheet being developed refers to project-based learning, which consists of the phase of identifying the problem by giving essential questions, designing project, arranging project schedule and implementing the project (Afriana et al., 2016). The evaluation rubric is developed to measure the

students' performance in their experiment, project report, presentation and their products. The evaluation resulted by using this evaluation rubric is used to measure the students' environmental literacy profile in the skill aspects. By using this evaluation rubric, students' environmental literacy profile can be monitored. This becomes the authentic evaluation based on the students' activities and proofs of their performance in the teaching and learning (Nuryantini et al., 2015).

To measure students' environmental literacy profile in the aspect of knowledge, attitudes, and behavior, a questionnaire is developed whose alternative answers use a scale with four alternative answers. The questionnaire consists of positive and negative statements to measure students' knowledge about environmental balance, attitudes, and behavior toward the environment. The indicators of the environmental literacy refer to the framework of Hollweg et al. (2011). The spread of each aspect being measured in the questionnaire of environmental literacy can be seen in Table 2. The total number of the statement is 78 statements with the choices of the answer are as follows: Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). For positive statement (favorable), the score for SA=4; A=3; D=2; and SD=1. In contrast, for the negative statement (unfavourable), the score for SA= 1; A=2; D =3; and SD = 4.

The Proper test is undertaken by validating the content by three experts validator. Validation is undertaken on the content for teaching and learning design, work sheet, evaluation rubric and environmental literacy questionnaire. The validators are asked to give feedbacks and comments for revision by filling in the validation sheet. The given answers for the validation use the following scales: relevant (R)=3, less relevant (LR)=2 and not relevant (NR)=1 (the result of the validation is presented in Table 3).

Overall, the result of the validation shows that both teaching and learning design and instruments are valid and is feasible to be used because the mean of the validators for all aspects reaches 80 %. However, there are five aspects which are regarded to be less relevant by one validator and therefore, they need to be revised based on the given suggestions. The validators agree that all the themes are relevant to the efforts to internalize Islamic values. In addition, the choice of teaching and learning model is regarded to be able to facilitate students to develop their thinking ability and to improve their environmental literacy.

**Tabel 2.** Environmental Literacy Aspects Developed in The Questionnaire

Environmental Literacy Aspects	Number of Statements		Total
	Positive	Negative	
Knowledge about environment	27	17	44
Attitudes toward environment	10	6	16
Awareness to act for the environment	9	9	18
Total			78

**Tabel 3.** The Results of Validation on the Content of Teaching, Learning Design, Instruments (n=3)

No.	Aspects Being Validated	% Response		
		R	LR	NR
A. Teaching and Learning Design				
1	The relevance of the theme with the internalization of Islamic values	100	-	-
2	Interrelation between theme and sub-themes	100	-	-
3	The relevance of each sub-theme with the environmental literacy aspects	100	-	-
4	The relevance of the teaching and learning objectives with the environmental literacy aspects	100	-	-
5	The accuracy of the main activities of teaching and learning being developed with the theme/sub-themes	100	-	-
6	The accuracy of the delivery of the main activities with the development of environmental literacy	100	-	-
7	The accuracy and suitability of teaching and learning steps in the sub-theme of 'Save our Water'	100	-	-
8	The suitability and clarity of teaching and learning steps with the students' activities developed in the sub-theme of 'Save our Water'	67	33	-
9	The accuracy and suitability of teaching and learning steps in the sub-theme of 'Save our Soil'	100	-	-
10	The suitability and clarity of teaching and learning steps with the student's activities developed in the sub-theme of 'Save our Soil'	67	33	-
11	The accuracy and suitability of teaching and learning steps in the sub-theme of 'Use Eco-friendly Product'	100	-	-
12	The suitability and clarity of teaching and learning steps with the students' activities developed in the sub-theme of 'Use Eco-friendly Product'	67	33	-
13	The accuracy and suitability of teaching and learning steps in the sub-theme of 'Waste for Life'	100	-	-
14	The suitability and clarity of teaching and learning steps with the students' activities developed in the sub-theme 'Waste for Life'	100	-	-
B. Work Sheet				
1	The suitability and accuracy of the development of work sheet for each sub-theme	100	-	-
2	The suitability of the content of work sheet with teaching and learning design	100	-	-

No.	Aspects Being Validated	% Response		
		R	LR	NR
3	The accuracy of the content of work sheet to develop environmental literacy	100	-	-
4	The relevance and clarity of the discourse in the work sheet	67	33	-
5	The relevance and clarity of the questions being asked in the work sheet	67	33	-
6	The clarity and the suitability of assignments with the project-based teaching and learning steps.	100	-	-
C. Evaluation Rubric				
1	The suitability of aspects being evaluated with the teaching and learning objectives	100	-	-
2	The suitability of aspects being evaluated with the assignments which have to be done	100	-	-
3	The clarity of the aspects being evaluated with the evaluation scale being developed	100	-	-
4	The completeness of the evaluation criteria with the evaluation scale	100	-	-

## CONCLUSION

Project-based teaching and learning program being developed has the characteristics as follows: (1) Developing students' environmental literacy based on Islamic values by using project based teaching and learning steps; (2) The main theme 'Green Living' is divided into four sub-themes: 'Save our Water', 'Save Our Soil', 'Use Eco-Friendly Products' and 'Waste for Life'; (3) The teaching and learning activities facilitate students to develop knowledge, skill and attitudes to build environmental literacy. The result of validation of the teaching and learning design, instrument and evaluation of the environmental literacy is regarded to be proper to be used. Based on the finding and the result of this research, it is suggested that: (1) The themes in the teaching and learning program design to improve the environmental literacy of the student teachers through project-based teaching and learning is being broadened to include other relevant themes with the environmental problems; (2) The program design being developed is better to be continued with testing and implementation widely by integrating the themes in other relevant subjects, especially in the Department of Natural Science.

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## IMPLEMENTATION OF PROBLEM-BASED LEARNING WITH GREEN CHEMISTRY VISION TO IMPROVE CREATIVE THINKING SKILL AND STUDENTS' CREATIVE ACTIONS

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### ABSTRACT

The aims of the research are to increase creative thinking skills and creative action through the implementation of Problem-Based Learning (PBL) model with green chemistry insight. The research design of mixed method experimental models embedded with a pretest-posttest control group was applied to measure the effectiveness of the application of the of Problem-Based Learning (PBL) model with green chemistry insight at the end of the learning activities to increase creative thinking skills and creative action of students in solving various environmental problems. The results showed that creative thinking before and after implementation of the experimental class is 82.42 and N-Gain 0.73 (high category), while that in the control class is 69.85 and N-Gain 0.32 (medium category). The assessment of the creative action begins from investigating groups of problem-solving ideas written on the outcome of the discussion groups. The consultation with the lecturer is carried out for the implementation of tasks, exhibit, communication (presentation), and rewriting in the form of reports in more detail results/products of the creative activity that has been done and also the sustainability of the action. The application of the Problem-Based Learning (PBL) model with green chemistry insight is able to increase creative thinking skills and creative action of the students.

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**Keywords:** Problem-Based Learning (PBL); green chemistry; creative thinking skills; creative actions

### INTRODUCTION

There are still many learners in Indonesia who have not been able to relate the scientific knowledge he studied with the phenomena that occur in his environment. This can happen because learners do not have the experience to link it during the learning process/lectures. At present, environmental issues are still an actual problem and a global issue (Tan, 2007). Environmental problems have an essential potential to be raised in chemistry learning. The benefits that can be felt directly would be very interesting and meaningful for learners. Lessons devoted to solving actual problems need to be designed through

an appropriate model and instructional medium to facilitate student activity linking concepts and the real world (Taufiq et al., 2016).

The weaknesses of environmental chemistry lectures during this time are revealed from student questionnaires. The explanation of lecturers is too dense with the material (topics) and field trips which objectives are less clear (Nuswowati, 2011). The impact is that students are less motivated to ask questions or improve their knowledge, and show they are not ready to make field trips. The impact of attitudes and behavior, when invited to field studies or out of lectures, has not been reliable as an example or paragon. The problem-based environmental chemistry lecturing model has been shown to increase students' character scores in solving environmental

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problems and can improve the mastery of environmental chemicals, but there is no significant relevance between improving mastery of material and improving character scores (Nuswowati & Taufiq, 2015).

The thinking ability of learners can also be developed by applying the Problem-Based Learning (PBL) model. Learners will be faced with a variety of contextual problems that require the ability to think and solve problems (Alejandro & Juan, 2010). Furthermore, according to Fatimah & Widiyatmoko (2014), the implementation of the model shows the learning achievement of learners increased and the ability to think learners also experienced a significant improvement. Construction of knowledge through learning, one indicator of success is the ability of identification and reasoning that serves as a problem solver (Özgelen, 2012). Scientific reasoning is developed through arguments arising from classroom communication (Acar et al., 2015).

Based on the description from previous experts and researchers, it can be said that Problem Based Learning (PBL) is a learning model that can apply the concepts and principles of science including chemistry of the environment, which is also more suitable to be studied through score appreciation (Yoonet al., 2014; Hicks & Bevsek, 2012). As we all know, the main cause of environmental pollution is the application of science. Science applications can have both positive and negative impacts on two sides of the coin. To deal with both impacts, learners need to be equipped with prevailing scores, so that the results of chemical technology directed only to improve the welfare of human life.

PBL is a model that prioritizes the suitability of learning with the things that are found in the daily lives of learners. This model conforms to CTL principles, namely inquiry, constructivism, and emphasis on higher-order thinking. Application of the PBL model can produce many desirable abilities in higher education (Sahin, 2010; Juntunen, 2013). Several relevant studies have been conducted about learning chemistry, environment, environmental learning, green chemistry, Problem-Based Learning approach, interrelated thinking skills (Nuswowati & Taufiq, 2015; Dhage, 2013; Nuswowati, 2011).

Green chemistry is a philosophy that encourages the design of a product or process that reduces the use and production of toxic and or harmful substances (Wardencki et al., 2005). The concept of green chemistry deals with Organic

Chemistry, Inorganic Chemistry, Biochemistry, and Analytical Chemistry. This concept tends to lead to applications in the industrial sector, but also has links to environmental chemistry. Green chemistry focuses more on efforts to minimize the income of harmful substances and maximize the efficiency of the use of chemical substances. Meanwhile, environmental chemistry emphasizes more on environmental phenomena that have been contaminated by chemical substances (Ravichandran, 2011).

The growth of the environmentally friendly chemical industry is increasingly needed. The trend is known as green chemistry or sustainable technology. Green chemistry arises from a shift in the traditional concept paradigm of concept efficiency that focuses primarily on the outcomes of chemical reactions, which can economically eliminate waste and avoid the use of toxic and hazardous materials (Zejnlagic-Hajric et al., 2015). Green chemistry activities are formulated as an efficient use of basic (especially renewable) materials, waste removal and avoidance of toxic and toxic reagents and solvents in industrial and chemical product applications (Jonassen & Hung, 2015).

Green chemistry movement has begun to be encouraged in Indonesia especially after seeing the impact caused by the chemical results that make scientists aware of the importance of green chemistry movement. This green chemistry also addresses issues of energy shortages, diminishing natural resources, current pollution problems, and many other key issues. Given the importance of green chemistry that has the potential to preserve the environment, this movement needs to be supported by all parties, especially the industry and government. Green chemistry is not going to solve all the pollution, energy, and food problems but its role can make an enormous and fundamental contribution to the preservation of life on planet earth. Based on the background encountered, the researchers apply Problem-Based Learning (PBL) model of green chemistry vision to improve creative thinking skills and creative actions of students. This study aims to improve the creative thinking skills and creative actions of students through the implementation of Problem-Based Learning (PBL) model vision of green chemistry.

Learning model that has the vision of green chemistry expected learners to build the concept into a science that enters long term memory so that learning result increases. Additionally, with

the application of learning models that have the vision of green chemistry, it is expected to facilitate the balance of hand on and minds on skills which is expected to improve students' learning outcomes as well as creative thinking skills and creative actions.

## METHODS

The method of this research is mixed method design with experimental models embedded through pre-test post-test control group to measure the effect of applying Problem-Based Learning Model (PBL) with the vision of green chemistry at the end of learning activity toward the improvement of creative thinking skill and creative action of the student in solving various environmental problems.

The populations of this study are students of Chemistry education of the fifth semester year 2016. Samples of the research are 38 students as the control class and 36 students as experimental class. The samples are taken randomly, after knowing that all classes are homogenous. Creative thinking skills are measured by a description test that modifies the indicator of creative thinking skills from Guilford (1977) for the reasons that best fit the stages of PBL. Initially, the drafting of the creative thinking skill test consisting of six questions of each environmental chemistry and the Hintz were created. The test of creative thinking skill comprised four subjects/topics carried out in this study. As a whole, there were 24 questions. After being tested regarding the validity, reliability, and creative thinking skills, there are 20 questions that meet the criteria to measure the creative thinking skills of students before and after the implementation of the problem-based and environmental chemistry-based teaching model with green chemistry vision.

To measure creative attitudes by using the adaptation of 32 point statements developed by Munandar (2009), it has been believed to reveal the general creative attitude. Of the 32 statements in the observation sheet of a marker of creative attitudes, there are positive statements and negative statements. In positive statement, answer "yes" got score 1, answer "no" got score = 0. In the negative statement, answer "no" got score 1 and answer "yes" got score 0.

The assessment of creative action begins with the investigation of a group of problem-solving ideas written from the results of group discussions. Utilization of consultation time with lecturer for task implementation, exhibiting,

communicating (presentation), and rewriting in the form of a report in more detail result/product of creative action has been done together with sustainability action.

According to Buntat & Nasir (2011), creativity is the ability to create something. Creativity is divided into a variety of types. It is not only seen from a product that one produces but also it can be seen through the performance of a person at the time of the task. The creative actions in this study were seen from student performance in group investigations focused on exhibiting (presentation) creative actions. Assessment of creative action involves seven aspects: (1) clarification of group investigation identification; (2) explanation of the source of the problem; (3) skill to predict the impact if not immediately addressed; (4) Smoothly answering or responding to questions from other groups; (5) working together in groups.

## RESULTS AND DISCUSSION

The effectiveness of the problem-based lecture model can be measured by measuring the difference between the students in the experimental class and the control class. Both groups are supported by the same lecturer. Before and after the lecture, pretest and posttest were done.

At the beginning of the lecture, both experimental class or the control class were given an agreement (lecture contract) stating that there is a different treatment. Control classes with lecture contracts are like those of past years, while the experimental class needs emphasis, especially on problem-based lecture synthesis and assessment techniques. Some environmental chemistry lecture deals for an even semester focus to support competence demands are as follows: (1) Be able to detect, recognize, and understand and respond to problems; (2) Able to predict pollutant sources and their impacts if not promptly addressed; (3) Be able to consider solutions or approaches to existing air pollution problems; (4) Be able to spark ideas in genuine and green chemistry ways to solve pollution problems; (5) Be able to detail action steps undertaken in solving the problem of pollution in which there are tables, graphics, pictures, models and or words.

The success of implementing PBL with green chemistry vision can be analyzed from several aspects. In this study, the focuses of analysis are thinking skill aspects and creative actions, as well as the students' response within the lecturing process.

### Creative Thinking Skill

Before and after the lecture, both control class and the experimental class were given a description test with the same problem. The results showed that creative thinking skills of experimental class before and after application were

82,42 and N-Gain 0,73 (high category), while control class 69,85 and N-Gain 0,32 (medium category). This increase is included in the medium category. The results of pre test, post test, and N-Gain of creative thinking skill are presented on the Table 1.

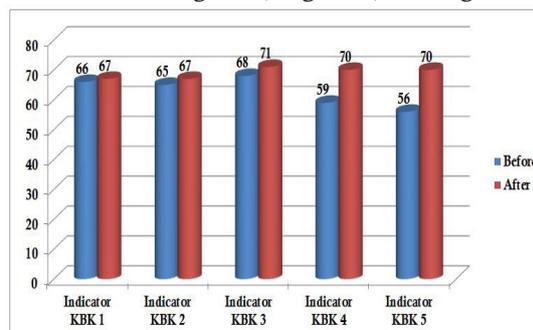
**Table 1.** The Scores of Creative Thinking Skill

Class	Pre-Test	Post-Test	N-Gain
Experimental	35.82	82.42	0.73
Control	55.94	69.85	0.32

The creative thinking skill test in the form of a test description that follows the steps or syntax of problem-based learning (PBL) vision of green chemistry was applied. The steps are different from those applied to control class that does not use the PBL steps with the task group presentation of the problem-solving action. The process of control class lecture is also a group task to create a paper presentation. The students made any paper about any theme on environmental chemistry. Titles are made mostly like the title of instructional material. All of the groups consisting of nine groups of control classes made titles that address the solution of air, soil or water pollution problems. In experimental classes, titles are created mostly like article titles. Six student groups (out of a total of 36 students) made titles that address the solution of air, soil or water pollution problems.

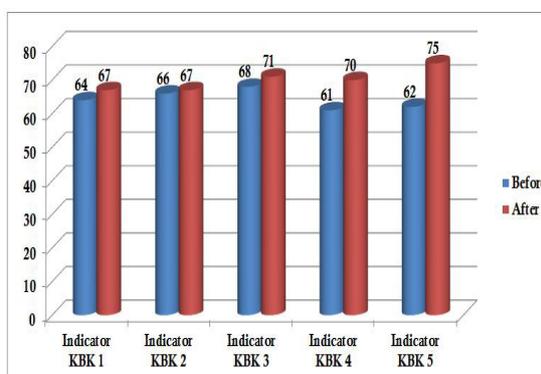
Creative thinking skills of each indicator with different subjects (air, soil and water chemistry) have been analyzed regarding scores on each aspect of assessment in each competency of the first year trial. The results of these trials analyzed the results of each indicator as a consideration in developing the assessment instrument. There are five predetermined indicators for creating creative thinking skills: (1) Able to detect, recognize, understand and solve environmental problems; (2) Able to predict environmental pollution sources and their impacts if it is not addressed immediately; (3) Able to consider solutions or approaches to solving existing environmental pollution problems; (4) Be able to spark ideas in original and Green Chemistry ways to solve environmental pollution problems; Indicator 5: Be

able to detail and design action steps undertaken in solving the problem of environmental pollution in which there are tables, graphics, pictures, models and or words. Differences in the score of the five indicators can be seen in each subject can be seen in Figure 1, Figure 2, and Figure 3.



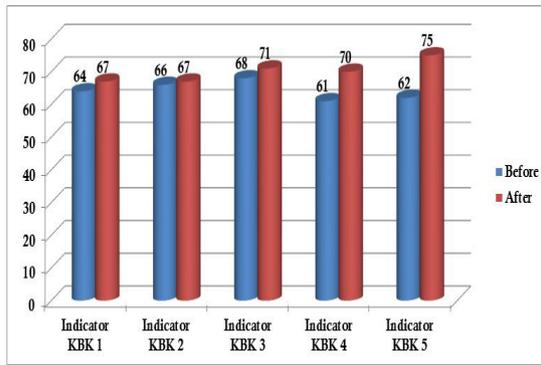
**Figure 1.** The Scores of Each Indicator of Creative Thinking Skill in The Subject of 'Air' in the Control Class

In the materials of 'air', the highest average score of the control class before treatment is at the third indicator of creative thinking skill with score 68. The lowest average score is at the fifth indicator with score 56. Then, the highest average score after treatment is at the third indicator with score 71, and the lowest score is at the first and second indicator with score 67.



**Figure 2.** Scores of each Indicator of Creative Thinking Skill on the Subject of 'Soil' in the Control Class

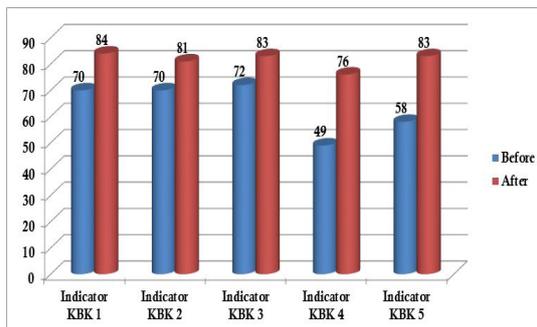
For the materials of soil, the highest average score of creative thinking skill in the control class before treatment is at the third indicator with score 68. The lowest average score is at the fourth indicator with score 61. The highest average score after treatment is at the fifth indicator with score 75 and the lowest average score is at the first and second indicator with score 67.



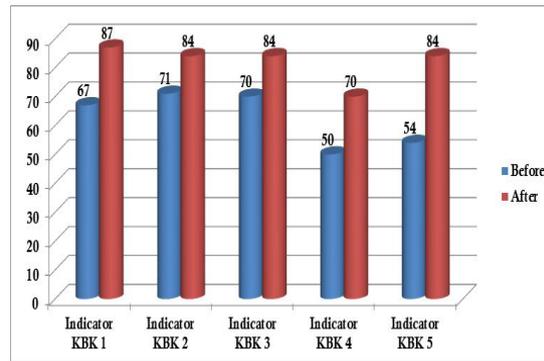
**Figure 3.** The Score of Each Indicator of Creative Thinking Skill in The subject of Water in the Control Class

In the materials of water, the highest average score of creative thinking skill of control class before treatment is at the fourth indicator with score 68. The lowest average score is at the fourth indicator with score 61. While after treatment, the highest average score is at the fifth indicator with score 75. The lowest average score is at indicator 1 and 2 with score 67.

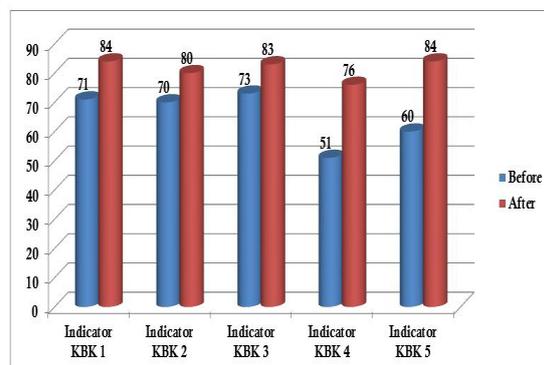
The lowest score of indicator before the learning process for control class is indicator 4 (triggering idea), the average scores of air, soil and water are 59.61 and 61 respectively. The lowest score also occurs in Indicator 5, the average score of air, soil and water are 56.62 and 62 respectively, while the highest score is indicator 3 (i.e., 68, 68 and 68). The draft action was performed. After the learning process, the lowest scores are indicator 1 (detect) and 2 (predict), while the highest scores are indicator 3 and 5. The score of all indicator of creative thinking skill after learning has increased although it is small. The highest scores in the control class are indicators 3 and 5.



**Figure 4.** The Score of Each Indicator of Creative Thinking Skill of Air Subject in Experimental Class



**Figure 5.** The Score of Each Indicator of Creative Thinking Skill of the Land Subject in the Experimental Class



**Figure 6.** The Score of Each Indicator of Creative Thinking Skill The subject of Water in the Experimental Class

The scores of creative thinking skills in the experimental class, before learning, on indicator 4, for subject air, soil and water are 50.51 and 49 respectively. The highest score of creative thinking skills for air, soil and water matter is in indicators 1 (87, 84, and 84) and indicator 5 (84, 84, and 83). The results of the assessment of creative thinking skills can be seen in Figure 4, Figure 5 and Figure 6.

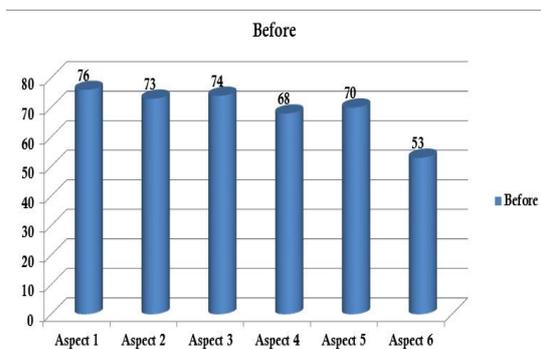
The indicators of creative thinking skills are applied in the learning process, and their assessment also refers to the PBL steps and the subject matter. It is very helpful in achieving the learning objectives, as Nuswowati & Taufiq (2015) mentions, that there are two fundamental processes, which occur during the process of creative thinking, i.e., cognitive (what we know), and non-cognitive (what we feel). The cognitive process is what the students know, not yet what is perceived, and bringing up the idea of problem solving. Non-cognitive processes such as the attitude of students to the problems around them

have not been trained in the current lecture process. This is particularly relevant to the research by Hajiet et al. (2015) and Rosita et al. (2014) that the application of learning tools based on green chemistry learning can improve mastery of soft skills and make learners motivated to be involved in problem-based learning with green chemistry orientation.

Improved creative thinking skills are also followed by improvements in other learning outcomes. It is increasingly asserted that the model of Problem-Based Learning with green chemistry is appropriate to apply to the environmental chemistry learning process since this learning model involves the learner's activities in the cognitive, psychomotor and affective aspects. This is by research by Tosun & Taskesenligil (2011) revealing that the Problem-Based Learning model can improve students' motivation and learning strategies. The students' cognitive learning outcomes are increased due to motivation and appropriate learning strategy.

### Creative Actions

The creative action data were obtained from the assessment of the prospective teacher presentation while displaying the report of the results of the group investigation. In the assessment sheet of group presentations, there are seven aspects that are assessed. The assessment results are shown in Figure 7.



**Figure 7.** An assessment of Creative Action through the Presentation of the Experimental Class Group

### Information

- Aspect 1 : Explain the identification of group problem
- Aspect 2 : Communicate the source of the problem and predict the impact if it is not addressed immediately
- Aspect 3 : Be able to consider solutions or approaches to existing air pollution problems

- Aspect 4 : Skillfully show off ideas
- Aspect 5 : Detail and design action steps to undertake.
- Aspect 6 : Fluently answer/respond to questions/objections/opinions of friends of other groups
- Aspect 7 : Work together in groups

The results of the assessment of creative actions indicate that the indicator 1 is the explanation of the identification of group problems and indicator seven that are working together in the group is the highest. Average assessment of problem identification is 76 and work together is 90. Indicators 2, 3, 4, and 5 are good too, with successive grades of 73, 74, 68 and 70, this is possible because, in lectures, it has been given clear guidance on the implementation of the presentation. Specifically, in the 6th creative action indicator that fluently answers/respond to questions/arguments/opinions of friends from other groups, the score is 53 which belongs to the category of very low. It is possible because if questions of friends are too broad, students are less able to answer and respond the suggestions from his friends. Based on these data, it is shown that this green chemistry is very good, in line with the research of Sudarmin (2013) which develops organic chemistry labs based on green chemistry.

The application of Problem-Based Learning (PBL) model is to attract and motivate students to follow environmental chemistry. This suggests that learners are more likely to follow the learning process by applying the Problem-Based Learning (PBL) model with green chemistry vision. It is proven by the questionnaire results of the responses of learners who partially agree.

The percentage of average students who gave opinion agree is as much as 89%. These results are in line with the results of the Tandogan & Orhan (2007) study, giving the result that the implementation of the Problem-Based Learning (PBL) model can motivate, enhance cooperation, and develop students' science process skills.

### CONCLUSION

The results showed that creative thinking skills before and after application in the experimental class were 82.42 and N-Gain 0.73 (high category), while control class 69.85 and N-Gain 0.32 (medium category). The assessment of creative action started from the investigation of the group of problem-solving ideas written from the results of the group discussion. Consultation

time with the lecturers was conducted for the execution of tasks, exhibits, communication (presentation), and rewriting in the form of reports in more detailed results/products of creative actions that have been done and been measured its sustainability. Application of Problem-Based Learning (PBL) model with green vision can improve creative thinking skill and creative actions of students.

The improvement of creative thinking skill is also followed by the improvement of cognitive learning outcomes with score 0.74 (high category). Some things become obstacles in this research and become suggestions for improvement for the next researcher. In the moment of group presentation in the classroom, the questions and responses must be by the issues raised by the presenting group. Assessing tools of creative thinking skills and creative actions need to be more developed so that it can measure the real performance of the individual. It is also suggested that the designated observer should know the importance of the evaluation tool. Researchers also recommend developing further research related to the assessment of creative attitudes with various other instruments, such as observation and portfolio.

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## VIRTUAL LABORATORY TO IMPROVE STUDENTS' PROBLEM-SOLVING SKILLS ON ELECTRICITY CONCEPT

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### ABSTRACT

The purpose of this study is to examine the effect of the use of virtual labs on problem-solving ability of students to the concept of electricity. The subjects were students of physics education at Mataram University. Students were divided into two groups: experimental and control group. The research instrument used was in the form of problem-solving ability tests on electricity concept. The tests employed the form of essay that represent concepts about electricity being studied. The results showed the effect of the use of virtual labs on problem-solving ability of students to the concept of electricity. It can be seen from the different improvement of problem-solving ability in both groups. Problem-solving ability of experimental group is higher than the control group. From the analysis of these problem-solving steps, it can be seen that general students in both classes have the same ability to identify problems and define goals. In the next step, the different improvement in problem-solving skills in the two classes is significant. Experimental class' students have a higher ability to plan and implement problem-solving solutions than those of control class.

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**Keywords:** virtual laboratory; problem-solving skills; electricity concepts

### INTRODUCTION

The laboratory has a very important role in Physics learning. The laboratory activities, students can be trained and equipped with some skills such as observing, classifying, measuring, communicating, interpreting data, and making conclusions. Laboratory activities make physics learning more interesting and fun. Most educators agree that laboratory activity is an important component of science learning. The research findings show that there is a relationship between experience in the laboratory and the development of metacognitive skills, and can inform the development of curriculum based on research (Sandi-Urena et al., 2012). Through student laboratory activities can develop academic and social skills. From a social point of view, students will be ac-

customed to appreciate the opinions of others, learn to communicate ideas, and working together in teams.

Some subjects can be learned in the laboratory are: First, students learn about the functions to the management of the laboratory. Second, the students learn to measure and compare the results with other similar quantities used as standard units. Third, the students learn to observe the objects they encounter. Fourth, students can also learn to do experiments in accordance with the instructions that are prepared or developed independently to achieve the goals set.

The limited equipment for physics experiments in Institute of Teachers' Education is still one of the problems. The equipment available is generally not comparable with the number of students. Laboratories and their support equipment require cost support for management, storage, laboratory maintenance, equipment and materials,

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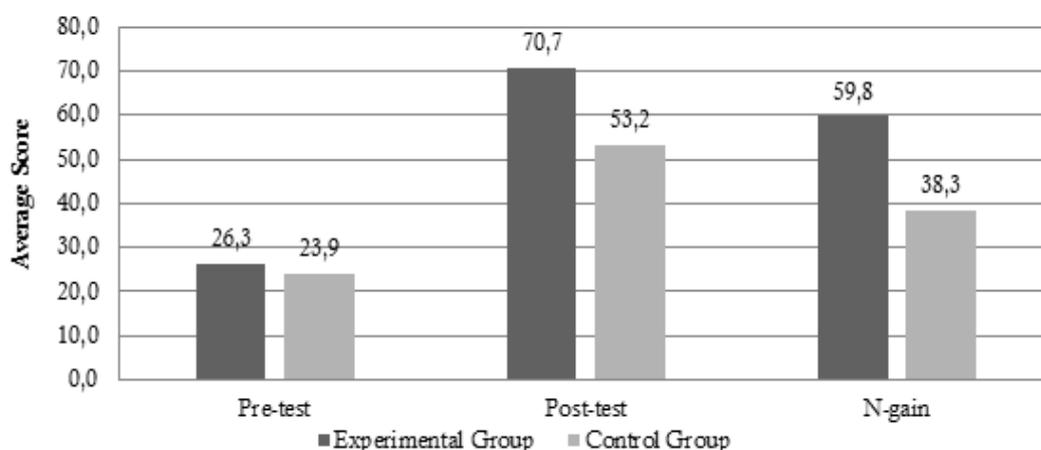
and availability of trained staff. This results in some experiments not being optimal, and some others are unworkable. In conventional laboratory models, students usually do not have much freedom to practice. This condition has implications for the low mastery of concepts and skills in solving physical problems, including electrical concepts.

The concept of electricity is one of the major concepts in physics. The concept of electricity in basic physics lectures include discussing Coulomb's law through Kirchoff's law. The learning of this electrical concept requires sufficient supporting experiments to be well explained to the students. As with other experimental devices, the electrical concept experiments were inadequate. This can be known from the results of physics laboratory observations on several Institutes of Teachers' Education in NTB. Most of the electrical concept is an abstract concept. This creates difficulties for students, because it is difficult to visualize the process directly through activities in the laboratory. This condition contributes to the low understanding and ability to solve student physics problems.

One of the innovations and alternative solutions that can be done is the utilization of computer technology for physics experiments. Computer technology can be adapted in learning to make it more interesting. In addition, it can be used offline or online, including combining face-to-face with online learning. Computer technology can be called a virtual lab. Harms (2000) defines virtual labs as computer simulations that allow experimental functions in a laboratory to be performed on a computer. Chen et al., (2010) defines virtual labs as software used for simulating the laboratory environment. Virtual labs can

be used when the tools needed for real experiments are too expensive, unsafe, and unavailable. Virtual labs allow learners to experiment and repeat over and over again, and provide an opportunity to observe how changes in parameters and effects are generated. A very important feature of a virtual lab for learners is to provide a learning experience of failure without causing any real damage. While Noor & Wasfy (2008) defines virtual labs as modeling, simulation, and information technology to create an interactive learning environment that suits both researchers and learners. According to Ciepiela et al. (2010) the keyword of virtual labs is experiment.

The main things to consider in learning with virtual labs include the applied approaches, strategies, techniques, and support facilities. According to Ahmed & Hasegawa (2014), virtual labs make it easy for learners to connect between theoretical and practical aspects without paper and pen. Finkelstein et al., (2005) argues, the implementation of physical practice can be done with computers, for example to collect and process data. Modifying a physics experiment to display a complete experiment is easier to do virtually inside a computer. The concept of physics to be experimented can be made in computer programs that are easy to use and learn. Gunawan & Liliyasi (2012) suggests that computers can be used to practice problems, games, to learn problem-solving. It is important to understand that experiments are virtually not intended to replace the role of real laboratory activity. The virtual laboratory is intended to be a supporter or an alternative to the unavailability of adequate laboratory equipment. Its use is expected to increase motivation and develop the ability to solve problems realistically.



**Figure 1.** Comparison of Average Scores of Problem Solving Tests on Both Classes

Researchers have found that the problem solving ability of learners can be trained and facilitated through the integration of problem-solving strategies and computer technology (Kim & Hannafin, 2011). The problem-solving ability has been recognized as an important skill to adapt to the environment in the 21<sup>st</sup> century (Kuo et al., 2012). The role of education in the 21<sup>st</sup> century should prepare learners to meet the challenges of a dynamic and interconnected world (Wüstenberg et al., 2014).

Training and equipping problem-solving skills has long been recognized as an important issue in education. Problem solving skills are not only important for work, but also to adapt to the environment (Hwang et al., 2012). Problem solving ability is the ability to use logic to solve real-life problems and make decisions, (Butterworth & Thwaitess, 2013). There are five steps in solving physical problems, namely (1) Identify and define problem; (2) Define goals and objectives; (3) Generate solution; (4) Make a plan for action; (5) Follow-up of the action plan. This stage is called the implementation phase of the solution

Hämäläinen et al., (2015) describes several important things to be able to solve the problem include: required support and resources for professional development related to problem solving in the work settings of various technologies, research-based knowledge needs to be fully applied to respond to changes, and work environments with the flexibility, authenticity and equipment used to support problem solving.

This article describes the effect of virtual labs on the ability to solve problems in electrical concepts. In addition to general discussion, this article also explains the level of acquisition and improvement of problem solving skills in both classes of each troubleshooting step.

## METHODS

The development of research has successfully developed a virtual laboratory model of the electric concept. Empirical model testing uses quasi-experimental research. The research sample is a physics teacher candidate at Mataram University which is divided into two classes namely experiment and control. Class experiments were studied using an electric virtual laboratory, while the control class was studied conventionally. The research instrument is a physics problem solving test through a description test. Data were analyzed using the appropriate statistical test using SPSS version 20. Data analysis included test: homogeneity, normality, and research hypothesis.

Improved student problem-solving skills can be determined through N-gain scores (Cheng et al., 2004):

$$N - gain = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \times 100\%$$

Note:

N-gain > 70% (High); 30% ≤ N-gain ≤ 70% (Medium); and N-gain < 30% (Low).

## RESULTS AND DISCUSSION

The lessons learned in this study use a developed virtual laboratory. Previously, students were given pretest to know their initial ability. While posttest is given at the end of learning to know the problem solving ability. The comparison of the test results and the increase values in the two classes is shown in Figure 1.

Figure 1 shows, initial ability in both classes is almost the same. In addition, it can be known from the homogeneity test results. Homogeneity test results show that the pretest data comes from a homogeneous group. Both are in the 'low' category. This indicates that both groups do not have enough knowledge to answer a problem. Through a treatment, the students' ability in both classes becomes increasing. However, problem-solving skills have differences in both classes. The average scores on the experiment class are higher than the control class. Comparison of the increase in the average score can be seen in the N-gain data of both classes. The increase in the experimental class is 59.8%, while the control class is 38.3%. Both classes are in the medium category. In addition to the homogeneity test, normality data is required to determine the data distribution pattern. Normality test results can be seen in Table 1.

**Table 1.** Normality Test of Problem Solving Ability in Both Classes

Kolmogorov-Smirnov test (K-S test)	Value of Sig.	Interpretation
Pretest in experiment class	.200(*)	Normally Distributed
Posttest in experiment class	.200(*)	Normally Distributed
N-gain in experiment class	.064	Normally Distributed
Pretest in control class	.044	Non-Normally Distributed
Posttest in control class	.200(*)	Normally Distributed
N-gain in control class	.200(*)	Normally Distributed

Table 1 shows the existence of non-distributed data that is in the pretest data of the control class. This implies the type of statistical tests to be performed for hypothesis testing. The solution of the non-normally distributed data in this case is using the Mann-Whitney test. This hypothesis test is based on the results of the student's problem-solving test which includes: test data and N-gain score. The results of hypothesis testing are shown in Table 2.

**Table 2.** Hypothesis Test Results

Mann-Whitney Test	Sig. Value	Interpretation
Pre-test	.453	There is no difference in the initial problem-solving abilities between the two sample groups
Post-test	.000	There is a difference about problem-solving abilities between two sample groups
N-gain	.000	There is a difference of N-gain score for problem solving between the two sample groups

Table 2 shows that the initial problem-solving abilities in both classes are not significantly different. This result explains the previous case in Figure 1. The impact of treatment on both classes has increased problem-solving abilities. However, Pretest results and N-gain scores for problem-solving abilities in both classes were significantly different. This data suggests that 'learning technology' using virtual labs is proven to help students improve their problem-solving skills. The results of this study are in accordance with several other studies.

Serin et al., (2009) found that 'learning technology' has a positive effect on the problem-solving ability of learners. Harskamp & Suhre (2007) argue, that the designed computer program allows learners to choose problems and use the instructions in different time from troubleshooting. Students who learn by using computer programs show there is an increased problem-solving ability than traditional learning. The use of instruction can help to explain the important parts in order to improve the problem solving skills of the learner. In addition, Ismail et al., (2016) explains that the implementation of virtual lab can be used to improve scientific literacy skills.

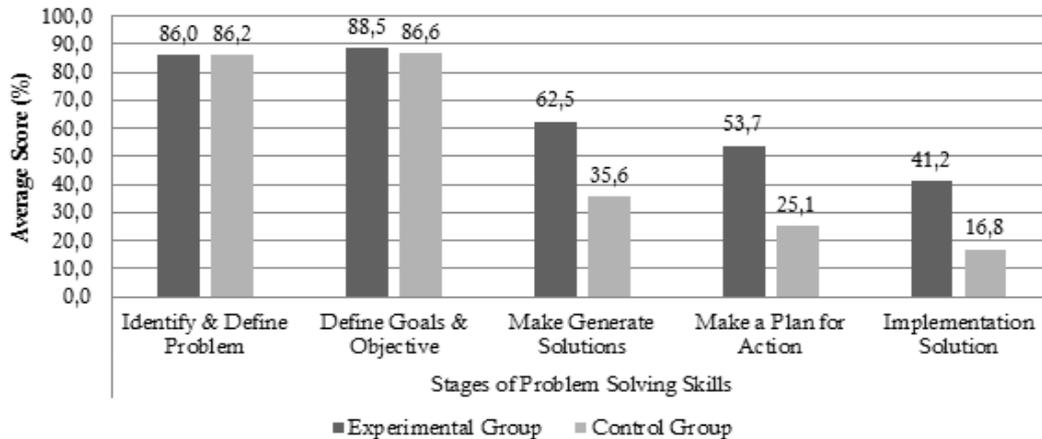
Experiments using virtual labs give students the opportunity to hypothesize and prove it in problem-solving. The virtual lab's system helps students to trigger their 'self-motivation' to learn actively. Student feedback shows that they work in an innovative environment and feel this model is more effective. The virtual lab is developed through design, testing and evaluation, and some necessary modifications. The results of the Serin, (2011) also found a statistically significant increase. The findings are related to the achievement and problem-solving skills of learners who study science and technology through computer-based learning. Mettas & Constantinou (2007) concluded that good technology could improve the development of problem-solving skills. The results analysis shows that technology contributes to the development of positive values and attitudes in educational technology. Also, technology has a significant effect on improving the understanding and implementation of problem-solving strategies in the technology domain. Technology brings enthusiasm and motivation in education. Technology began to be considered an important educational activity that can help in their future careers.

According to Oidov et al., (2012) virtual laboratories in the learning process are useful to provide learners with the opportunity to learn by doing, exciting, motivating activities to discover, ensuring classroom interaction through discussion and debate, develop thinking skills and problem-solving skills, and open up possibilities by using different types of resources for self-study.

In virtual labs learning, most student activities are performed on a computer. Students are given problems, some information, and software that they can use to test ideas. The next step is left entirely to the students. Each student should be able to identify the needs and develop the appropriate design, test the experimental design, and analyze the suitability of the original plan with the results already obtained, then revise and re-experiment if necessary. The results of Gunawan & Liliyasi (2012), show that virtual labs are used to improve students' critical thinking disposition. Learning with virtual labs helps students to make correct inferences. Virtual labs are also helpful to increase user interest and motivation, strengthen their skills and provide full-time security (Gorgiu et al., 2009). Virtual labs increase the interest of learners, they feel much more relaxed than real laboratories, improve the quality of learning, and they are not tired while working with virtual labs (Limniou et al., 2007).

Yusuf & Subaer (2013) have also shown that learning based on virtual lab media is able to activate learners. Most students strongly agree with the use of virtual labs in physics learning. Nance et al., (2009), argues that in addition to supporting educational activities, virtual labs can be used to support research activities. The ad-

vantages of virtual labs are to assist researchers in terms of: First, being able to remotely access experiments, analyze data, or generate reports; Secondly, accelerate the dissemination of product results; Third, record the complete documentation during the study; Fourth, doing experiments repeated over different parameters.



**Figure 2.** Comparison of Capabilities According to Problem Solving Stages in Both Classes

An additional advantage of using virtual labs that can be accessed remotely is: the research team can split the test location without having to be present in the same location. Users can also access laboratory resources, collect experimental results, even share ideas from anywhere.

Cruz-benito et al., (2014) states that 'virtual models' open up new opportunities for learning and learning resources. This model allows learners to interact with their virtual resources to make measurements and assessments. Furthermore, the ability of this platform gives the learners the power to know how they learn, opens up new ways to learn progress in learning and can help to motivate, ultimately not only to view the virtual world like video games, but also as a virtual environment for learning purposes.

During the research, virtual laboratories and supporting devices were adapted to improve student problem solving skills. This is important because of the variety of student learning styles. The instrument used is a combination of conceptual-procedural problems and mathematical calculations. This learning style should be considered because in previous research conducted by Gunawan et al. (2016) have found that the implications of the 'problem concept' used have differed in the mastery of students' physics concepts based on two sample groups. Likewise for the 'learning style', learners are visual and auditory style is very helpful to learn by using the computer, while kinestetik style needs other support

in computer-based learning. Views on virtual labs programs and spreadsheet instruments are prepared as a solution to solve the problem.

The increase in problem solving skills in the experimental class is the influence of the treatment given. Based on the observation of the researcher during the learning, it can be seen the effect of treatment at each stage of learning. Each stage is to train students' skills to solve problems. The scores of problem solving skills are measured based on the analysis of each step of the problem solving during pretest and posttest. The result of problem solving analysis for each step is shown in Figure 2. The steps of the problem solving include: (1) Identify and define problem; (2) Define goals and objectives; (3) Generate solution, (4) Make a plan of action; and (5) Follow through.

Based on Figure 2, it can be seen the increasing score of each step problem solving abilities. The ability of both classes is identical in step 1 (Identify and define problem) and step 2 (Define goals and objectives). In this step, the ability of both classes has a high score. This indicates that most of the students are able to recognize and understand the problem on electrical concept very well. Identifying the problem is an important component to solve the problem in the next step. The ability of problem identification and goal setting helps the student in recognizing the problem, categorizing, and defining the solution plan.

Lin & Singh, (2009) describes his research that, categorizing problems by students for

further physics lectures. In addition, it can be a useful tool for understanding student patterns in identifying problems and reflecting on how to solve them. There are differences in identifying problems at different levels of the course. In basic physics courses, identification is applied to the basic principles but relevant to the problem. Meanwhile, in advanced courses such as quantum mechanics, identification is focused on concepts and procedures to 'solve problems'. According to Lin & Singh (2013), identification of relevant physics principles is one of the important components to solving physics problems. In some cases, the same student problems have different solutions in applying the concept of physics. Students need help to apply their knowledge in different situations.

In the next step (steps 3, 4, and 5), the ability of the experimental class is higher than the control class. This means that, learning the concept of electricity through a virtual lab provides opportunities for students to solve problems systematically. Students are able to experiment as much as possible without destroying the tool and make it easier to connect a concept with others. In addition, students are more flexible in proving ideas to improve problem-solving skills. This condition as a motivation for students to feel comfortable to work in front of the computer screen. Klegeris & Hurren (2011) found that the ability of learners to solve problems increased significantly. The satisfaction and motivation of learners has been proven to help the next stage become easier. The reason is, learners enjoy the process, benefits, and progress in themselves.

The practice of applying the concept that has been found is one of the factors of problem solving ability that can be improved. Providing more opportunities makes students more experienced in solving physics problems. Nirmalakhandan (2013) argues that learning achievements and problem-solving skills of learners can be improved through practice, and computer-based assessment. In addition, Harskamp & Suhre (2007) found that the program was able to improve students' analytical skills, using tools, and a solution approach. The experiment group is superior to all the steps in solving the problem, but some instructions are used incompletely.

For example, virtual labs will make it easier for students to transfer what they learn from one context to another. It is a useful tool to help students understand the application of physics principles in different situations and develop a coherent structure of physical knowledge. According to Perels et al., (2005) problem-solving

ability can be enhanced by continuous practice to solve problems and self-regulatory.

Utilization of virtual labs in electrical concept learning is a blend of theory and practice. It is proven that the students are able to improve their problem solving skills. The interactive display of images and simulations in the program is to help students recall the material discussed earlier. Carson (2007) explains that his knowledge and application are the main principles of theory and practice to solve problems. This means that educators are easy to connect students' lessons through daily problems. Learners are given the knowledge to solve the problem.

Virtual labs that are used contain problems to practice, recognize the problem, and solve the problem. Visual forms in the virtual lab help students to build concepts and summarize them. This is supported by several research results. According to Shih et al. (2016) the visual form helps students to answer the questions given. Additional knowledge resources help students to answer difficult questions Gunawan et al. (2013) has proven that physics learning through virtual labs helps students to improve their abilities by logic inference and construct physics concepts.

In addition Lin & Singh (2013) find that learners will be easy to solve analog problem-solving processes and transfer their learning in different situations. An interesting experience for students if always given practice and feedback during a learning session. Çevik (2015) also resulted that feedback in online learning activities is to improve students' ability in problem solving. Subali et al. (2017) also supports that experiments using computer programs help students to improve students' literacy skills, particularly in designing graphs and predicting.

This research assumes that the application of problem solving to each student is the ability of the class. This effect is similar to (Hämäläinen et al., 2015) which also assumes that the problem-solving ability is personal. However, in the future, to solve complex problems at work. The ability to network and share problem solving is more necessary than individual skills (Hämäläinen & Vähäsantanen, 2011). This becomes interesting for further research.

The lowest increase in step 5 occurs in both classes. Some literature considers this step is the implementation of solutions in problem solving. This step is a follow-up to the problem. Students are expected to solve the problem thoroughly and appropriately. In the control class, there was an increase in this stage averaging 16.8% (Low category), while the experimental class was 41.2%

(Medium category). These results indicate that, the average score increase in the experimental class is higher than the control class. Analysis of student answers indicates that some students have difficulty in solving problems appropriately. This becomes the future finding to continuously improve the quality of learning so that problem solving ability at each stage is better.

Although virtual labs provide positive results to improve problem solving skills, there are limitations. The limitation is that experiment class activities are not all recorded, so there are patterns of interaction, discussion, and other interesting events in the problem solving stage can not be fully analyzed. There are several difficulties to use virtual laboratories: (a) recommended computer standards; (b) required staff; (c) instructors who are expert in the learning model; and (d) other technical constraints during the research.

### CONCLUSION

The conclusion in this research is the application of virtual laboratory in electrical concept has a positive effect on student problem solving ability. The increase in problem solving skills of the two classes is different. However, the experimental class problem-solving capability is higher than the control class. Students have similar capabilities in steps 1 and 2 which are identify and define problems; define goals and objectives. Meanwhile, in the next step, the ability of experiment class is higher than control class. This shows that the application of virtual labs in electrical concept learning helps students to improve their ability to solve physics problems.

Students should be familiar with the virtual lab features so they can learn regularly. This will make it easier to achieve goals. Time management must be precisely configured to make it easier to achieve the goal. Further research is suggested to focus on other skills that can be developed for virtual lab learning. Student response patterns, different problem-solving abilities, and gender-evaluated outcomes, are interesting to investigate.

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## CHARACTERISTICS OF THE ABILITY OF PHYSICS CONCEPT IN ENRICHMENT TEACHING MATERIALS OF NATURAL AND MINERAL RESOURCES (NMRs) LITERACY

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### ABSTRACT

This study is aimed at describing the characteristics of basic physics concepts in materials of science literacy enrichment of natural and mineral resources (NMRs) prepared by students of Physics Education Department, Universitas Islam Negeri Sunan Gunung Djati Bandung. The method of data collection for scientific literacy ability of NMRs is obtained from the description of NMRs, results of describing the enrichment materials of NMRs process, the basic concepts of physics, and context as well as attitudes of students towards NMRs through paper enrichment materials. This study was conducted to 15 documents of enrichment materials made by students. The study concluded that: (1) characteristics of students' ability to describe the physics concepts in literacy enrichment materials NMRs show variation; (2) the ability of describing concept of fundamental physics in five NMRs groups being investigated shows a low gains. The study recommends that the application of material needs developing and teaching media literacy enrichment and physical sciences should have more contextual NMRs for secondary, high school and undergraduate students.

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**Keywords:** characteristics of basic physics; enrichment materials; literacy of natural and mineral resources

### INTRODUCTION

Republic of Indonesia has abundant natural and mineral resources (NMRs). This potency also becomes a set of asset, which may be explored, developed and used for the purpose of Indonesian citizens' prosperity. As matter of fact, the potential NMRs, which are in the form of water, land and air resources, are all available in all Indonesia's region. These NMRs, in fact, is part of human's integrated environment. Therefore, the bigger potential of NMRs is to explore the greater benefit that Indonesian citizens may obtain.

The reality shows that Indonesian citizens do not fully get the benefit of the availability of po-

tential NMRs in their regions yet. They still have limited access in using those potential NMRs. Greater than that, they also provide insufficient involvement in managing the NMRs. Specifically, only artisans and unskilled labors who actively get involved in such activity. Yet, citizens also lack of comprehension or literacy upon their surrounding NMRs. Such limitation towards NMRs is not shown by half of students living within the NMRs location, but also by college students from regions with potential NMRs. They do not have enough literacy, especially in the concepts of science or physics found in NMRs management.

Literacy towards NMRs is included in scientific literacy. Students or college students who know the scientific concepts will also have sufficient literacy in NMRs. Recently, there are students with low ability of scientific literacy, which can be seen in their low concern in NMRs

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management (such as water resources) (Hidayati, 2016; Arief & Utari, 2015). In fact, the amount of such potential NMRs is not balanced with citizens' awareness in involving themselves upon the use of mineral resources. Nowadays, citizens do not have sufficient literacy in the value of the abundant NMRs yet (Eheazu, 2014; Allman & Daoutidis, 2016; Kusmana & Hikmat, 2015). In order to have sufficient literacy on NMRs they need to obtain enough information through the implementation of briefing and provision of NMRs enrichment teaching materials (Rusli, 2016; Hobson, 2003; Purwanto et al., 2014; Rochman, 2015). Moreover, there are numerous researches on the effort of the improvement in such ability with various strategies (Khaeronytyas, et al., 2016; Fakhriyah, et al., 2017; Setiawan, et al., 2017; Setiawati & Rusilowati, 2013). The presentation of literacy enrichment teaching materials may also be used as scientific materials which are based on research result (Parmin & Peniati, 2012).

According to the abovementioned conditions, therefore the researchers decided to review the Characteristics of students' ability, especially in college, towards the NMRs. The last but not least, the researchers also aimed to figure out the way the information of enrichment teaching materials of NMRs involves the basic physics concepts (Zakiyyah et al., 2016; Yuliati, 2013).

## METHODS

This descriptive and collaborative research was based on the identification of a series of activities and products performed and produced by a group of respondents (college students) on NMRs. Such activities started with the planning of NMRs to be learnt. Collection of initial information relating to NMRs was followed by NMRs location survey and collection of information and products submission. At the end of the activity, the researchers conduct the data analysis and interpretation.

This research was applied to college students living in 15 location in West Java, which consisted of 5 water resource locations, 2 forest resource locations, 1 waste resources location, 1 geo-park location, and 3 natural sand resources. All data were collected in a paper document containing four open questions to guide the college students in compiling the enrichment teaching materials of NMRs. The researchers then sco-

red the answers and descriptions proposed by the college students on the four literacy questions to the range of 0-5 (adapted from Holden, 2010; Peranginangin, 2014). The score range shows that 0=non-filled; 1=inadequate expressions and some are false; 2=inadequate true expressions; 3=most of the expressions are true but less comprehensive; 4=all the expressions are true but less comprehensive; and 5=all the expressions are true and comprehensive.

## RESULTS AND DISCUSSION

### Characteristics of the college students' ability of concept revelation, process, contexts and attitude

Characteristics of the college students' ability of concept revelation, process, context and attitude to the enrichment teaching materials of NMRs literacy can be described in the Table 1. Based on Table 1, 15 documents of enrichment materials of natural and mineral resources come from 15 places in West Java. The materials are described based on components of concepts, process, context, and attitude. The students ability in describing the concepts are varied. The variation takes place from the highest to the lowest i.e. describing positive attitude (2.53), describing process (2.31), describing context (2.28), and describing concepts (2.26). The result shows that despite the low ability of describing concepts, the students have high positive attitude. The positive attitude can be in the form of caring dealing with the use and risk of using natural and mineral resources. Generally, the students' ability in describing the materials is still low (2.35–below the average score on 0.5 scale).

The ability of describing the conceptual components only scores 2.26. The students' ability in describing and identifying concepts of Physics in the materials of natural and mineral resources is also still low. The low ability results in the decreasing supports of environmental resources (Goldman et al., 2014). The next low score occurs in the ability of describing context (2.28).

For instance, in the aspect of concept, their most prominent literacy were in water and natural sand resources. Meanwhile, they had insufficient comprehension on concept related to forest and waste resources. In fact, forest resources has economic function, which exceeds the management cost (Purbawiyatna et al., 2011).

**Table 1.** The Average Scores of Describing Ability in The Teaching Materials of Natural and Mineral Resources

Natural and Mineral Resources	Concept	Process	Context	Attitude	Average
Waterfall of Tasikmalaya	2.7	2.3	2.1	2.7	2.45
Reservoir Water of Sukabumi	2.5	2.3	2.1	2.6	2.38
Tanjung Water of Tasikmalaya	2.6	1.9	2.2	2.5	2.30
Katulampa Dam of Bogor	2.2	2.5	2.2	2.8	2.43
Water Resource of Sukabumi	2.6	2.5	2.2	2.5	2.45
Palm Sugar of Sukabumi Regency	1.8	2.2	2.3	2.5	2.20
Eucalyptus of Indramayu	1.9	2.3	2.5	2.3	2.25
Cow dunk of Bandung City	1.8	2.2	2.2	2.4	2.15
Geopark of Sukabumi Regency	2.1	2.4	2.5	2.3	2.33
Unused river of Bandung	1.9	1.9	1.8	2.3	1.98
Rubber Waste of Tasikmalaya	1.9	2.1	2.1	2.2	2.08
Rice Husk of Tasikmalaya	2.1	2.2	2.3	2.6	2.30
Galunggung sand Tasikmlaya	2.6	2.7	2.5	2.9	2.68
Sand Majalengka	2.7	2.6	2.6	2.6	2.63
Sand Bandung	2.5	2.5	2.6	2.8	2.60
Average	2.26	2.31	2.28	2.53	2.35

#### Characteristics of the average ability in revealing the Physics concept literacy

Characteristics of the college students' average ability in revealing physics concept literacy in enrichment teaching materials of NMRs may be described in the Table 2. According to Table 2, the Characteristics of college students' ability in revealing the physics concept, which was described through the enrichment teaching materials of NMRs, showed particular variation, with the range of 1.9 to 2.68 and at the scale of 0-5. By the range of 1.9 to 2.68. The average score amounted to 2.35 was still below 2.5. Such higher point showed that other than the variation, their ability in revealing the physics concept of each NMR in many regions in West Java remained low. Similar with the other researches, the researchers also figured out that students need to obtain appropriate training to access numerous literatures. Besides, college students should be trained to explore higher thought ability, such as when they observe the potential natural resource in their surroundings (Fakhriyah et al., 2017).

Among the fifteen places of natural and mineral resources, there are only five students achieving scores which is higher than 2.5 in describing the concepts of physics. They are the ones describing the waterfall of Tasikmalaya (2.7), Tanjungwater of Tasikmalaya (2.6). Water Resource of Suiabumi (2.6), Galunggung Sand of Tasikmalaya (2.6), and Sand of Majalengka (2.7). The five students come from the places close to the natural and mineral resources. Moreover, the

mining and distributing activities are easily observed by people. It shows that the close distance between the people and the natural and mineral resources influences the people's understanding and care of natural and mineral resources (Peraningin, 2014). Another finding shows that the students are more concerned with the development of sand materials. The students have good understanding and attitude upon the impact of sand mining in Majalengka and Galunggung Tasikmalaya (Suhermana, et al., 2015).

**Table 2.** Students' Ability in Describing Literacy concepts of Physics in The Enrichment Materials of NMRs

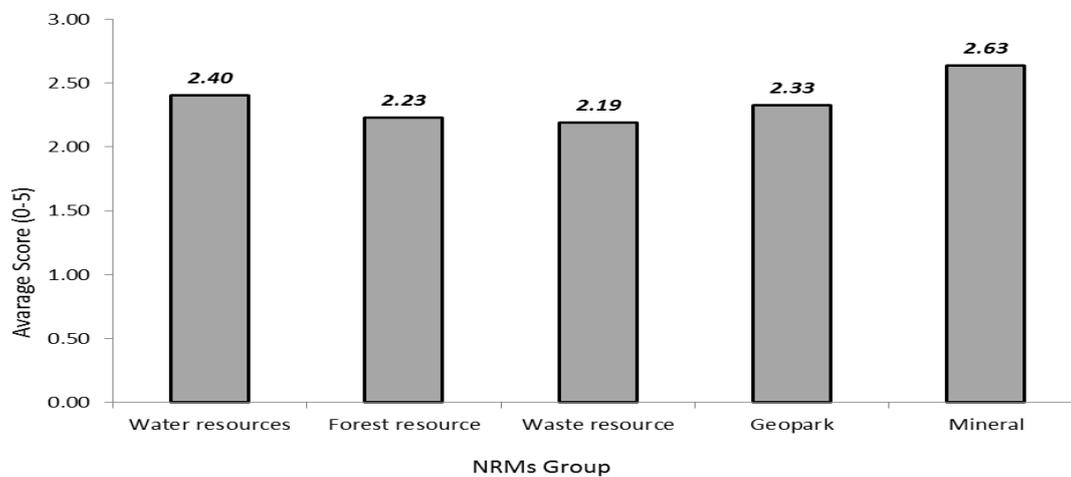
Natural and Mineral Resources	Concept
Waterfall of Tasikmalaya	2.7
Reservoir Water of Sukabumi	2.5
Tanjung Water of Tasikmalaya	2.6
Katulampa Dam of Bogor	2.2
Water Resource of Sukabumi	2.6
Palm Sugar of Sukabumi Regency	1.8
Eucalyptus of Indramayu	1.9
Cow dunk of Bandung City	1.8
Geopark of Sukabumi Regency	2.1
Unused river of Bandung	1.9
Rubber Waste of Tasikmalaya	1.9
Rice Husk of Tasikmalaya	2.1
Galunggung sand Tasikmlaya	2.6
Sand Majalengka	2.7
Sand Bandung	2.5
Average	2.26

### The Characteristics of Students' Ability in Describing the Enrichment Materials based on the Grouping of NMRs

NMRs may be categorized into 5 types: water, forest, waste, geopark and sand/mineral. The Characteristics of the average ability upon revelation which was based on NMR groups may be explained in the following Figure 1.

According to Figure 1, the Characteristics of the NMR groups' average ability upon revelation, which was described through the enrichment teaching materials of NRMs, remained in low scores (scale of 0-5). The highest score upon the ability in revealing the physics concept of NMR groups by college students was 2.63, which was concerning sand/mineral NMR and respectively

followed by water (2.41). Furthermore, geopark reached the score amounted to 2.33, while forest was 2.63. Unfortunately, they were included in low score. The last score was for waste resource, which were only 2,19. The researchers also figured out that the most revealed physics concept composed several things, they were: material, mechanics, basic plane, transportation, physical change, force and energy, collision, physics of earth, types of rock and gravitation. Meanwhile, in case of waste resource revelation, college students indicated their lack of physics concept revelation. This possibly happens since waste does not have many correlations with physics concept. The prominent revelation of physics concepts included fluid, evaporation and heat.



**Figure 1.** Characteristic of The Student Ability in NRM Enrichment Material Description

In case of sand and mineral resources, the most revealed physics concept was related with the exploitation process of rocks turning into sand, which is well known as gravitation. Such concept was revealed during rock scraping by using numerous mechanical tools such as crowbar (traditional) or beco and sand truck. Moreover, there was the revelation of types of mineral materials such as sand, gravels, rocks, clay/soil and limestone. Sand mining is always connected with its impact towards the condition of the land and water in related area. The quality of land and water surely will be decreased, which results in negative effect for citizens in such area (Suhermana et al., 2015). This revelation is in line with the other researches, which state that science teachers should encourage their students to be able to implement science in maintaining and preserving the environment wisely (Parmin et al., 2015).

### CONCLUSION

The researchers conclude that: (1) the Characteristics of the college students' ability in describing the physics concept in enrichment teaching materials of NMRs shows the differences based on the characteristics, location, and phenomena; (2) their ability in revealing the physics concepts are low, since the revelation remains in general or macro concepts. Therefore, in accordance with the result and discussion, the researchers suggest that the development and implementation of enrichment of more comprehensive teaching materials as well as contextual learning media of physics literacy upon the NRMs should be conducted, especially to elementary, high school and college students.

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**STUDENTS' ABILITY OF SCIENTIFIC INQUIRY WITH MULTIMEDIA  
IN CELL REPRODUCTION MATERIALS****R. Cahyani\*<sup>1</sup>, Y. Hendriani<sup>2</sup>**<sup>1</sup>Universitas Islam Nusantara, Indonesia<sup>2</sup>Pusat Pengembangan dan Pemberdayaan Pendidik dan Tenaga Kependidikan, Bandung, Indonesia**DOI: 10.15294/jpii.v6i2.9484**Accepted: April 17<sup>th</sup>, 2017. Approved: July 30<sup>th</sup>, 2017. Published: October 17<sup>th</sup>, 2017.**ABSTRACT**

This study aims to: (1) explore students' learning achievement based on scientific inquiry learning on the materials of cell reproduction reflected on pre-test and post-test; (2) obtain the achievements of scientific inquiry activity based on the different time of problem distribution; and (3) analyze students' ability in scientific inquiry activities based on the indicators of scientific inquiry in the different time of problem distribution. The design was research & development. The participants were two classes of PGMI. The research data were pre-test and posttest obtained from close-ended test and scientific inquiry activities obtained from student worksheet. Research shows that learning outcomes of students in each class increases, though there is not any significant difference in the increase indicated in the learning outcomes between the two classes. The technique of distributing students' work in different time influence the students' scientific inquiry activity. Communication is a dominant indicator of the successful scientific inquiry activities in both classes. Using the data and creating an image are other indicators affecting the scientific activity.

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**Keywords:** scientific inquiry; cell reproduction**INTRODUCTION**

Cells are the smallest parts that make up human bodies. Each cell can multiply by forming new cells through a process called cell division or cell reproduction. In single-cell organisms (unicellular), such as bacteria and protozoa, the process of cell division is a way to multiply. In multicellular organisms, cell division leads to increased body cells. Cell division is an important factor in our lives (Campbell et al., 2002; Pelczar, 2008). The study of cell reproduction mainly related to microorganisms is important to do because it is closely associated with the quality of human life that is the spread of disease. Attitudes toward science in understanding environmental, medical, and social issues are essential to the prosperity of society (Shah & Khan, 2015).

Teaching effective science depends on the availability and organization of materials, tools, media, and technology. The National Research Council (NRC) recommends that teachers have the authority to choose the right materials, media, tools, and technology in teaching their students. Students are also taught to evaluate and interpret the information they gain through many resources in order to develop their scientific understanding. Meanwhile, Thoron & Myers (2012) said that teachers should be able to create a learning environment based on real life problems, to ask questions from learners and to expand their thinking outside the context of the lesson.

Cell reproduction materials can be learned with the help of multimedia to improve students' understanding. A conventional teaching method that occurs in the classroom is monotonous, less participatory and often unable to arouse students' curiosity and interest, especially in science sub-

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jects such as Biology (Aggarwal & Dutt, 2014). Mayer (2003) suggests that students learn from well-designed multimedia presentations rather than just traditional oral or text presentations. Anggarwal & Dutt (2014) delivering instructions through multimedia presentations offers tremendous opportunities in acquiring biological concepts as they as educators are able to present better information, examples, illustrations, to solve problems for students, and to build knowledge, which is to help to illustrate abstract conceptual principles.

Multimedia becomes an important tool in biological sciences because it has the potential to provide new learning environments and pedagogical applications to foster student interest, involve students in the research process, encourage critical thinking, problem-solving skills, and develop conceptual understanding of cell biology topics (Bockholt et al., 2003). The results of study concluded that the potential of multimedia related to the cancer cell in Biology could facilitate student learning. Multimedia is able to present active learning towards different learning styles and the most effective pedagogy for learning science. Various designs of multimedia can serve as developers, enthusiastic feedback from teachers and students, learning motivation and a sense of responsibility in educational and research development innovation (Liu et al., 2014).

Science as a process is related to the way of working to gain products. It is called scientific process from which scientific products can be gained. Science is an empirical knowledge discussing facts and environmental phenomena. That is why the learning process should provide facts which means that the learning process does not only provide verbal process like what happens in traditional learning. Teaching science in elementary school means teaching the mastery of products and process as well as teaching the scientific attitude (Yuhanna & Retno, 2016). Ideally, all teachers should have all competencies in the scientific work to improve the quality of learning both in knowledge and social life. This is because the teachers are the head spears of teaching. Started from studying in a teacher department, scientific work should be taught in solving the faced problems (Ariesta, 2011).

Meanwhile, the Indonesian government through the 2013 curriculum emphasizes the learning process at the school to implement a student-centered learning scientific method. Through the implementation of scientific methods inquiry, problem-based learning, project-based learning, and discovery learning, Natural Science and So-

cial Science subjects are developed as an integrative science and integrative social studies, not as a separate disciplinary education. Learning is applicative and potential to improve thinking ability, learning ability, curiosity, and to foster a caring and responsible attitude towards social and natural environment.

The emphasis of this learning method is in line with the National Research Council (1996). Standard B of the National Research Council (1996) states that science educators should encourage Scientific Inquiry Skill, as well as curiosity, openness to new ideas and data, and skepticism that characterizes science. Furthermore, National Research Council (1996) states that scientific inquiry is a multiphase activity involving observation; asking question; examining books and other sources of information to see what is already known; planning an investigation; reviewing what is already known in experimental evidence; using tools to collect, analyze and interpret data; proposing answers, explanations, predictions; and, communicating the results. Scientific inquiry requires the identification of assumptions, the use of critical and logical thinking, and considerations of the explanation.

Many educators are less likely to adopt inquiry learning on the consideration that it is still difficult to apply it to learning materials. Edelson et al. (1999) in their research suggests that the implementation of inquiry learning in the classroom presents a number of significant challenges. The challenges are: (1) lack of motivation; (2) low accessibility; (3) low knowledge background that makes investigation becomes less meaningful; (4) activity management capability; and (5) practical constraints of the learning environment. Other reasons that often arise include the lack of time to conduct an investigation. The use of multimedia is expected to streamline time and as a source of practical information to conduct investigations.

Referring to the usefulness of multimedia and inquiry model in the learning process, it is necessary to conduct a study about students' multimedia-assisted scientific inquiry ability on learning cell reproduction. The objectives of the research are: (1) to investigate the results of student learning on scientific inquiry on cell reproduction material based on the pre-test and post-test; (2) to investigate the results of scientific inquiry activities based on the time of giving different problems; and (3) to analyze students' scientific inquiry ability based on scientific inquiry activity indicator with problems distributed in different time.

## METHODS

The type of research is Research and Development (R&D) because this study developed the program and implemented it in several classes. The research implementation used quasi-experimental design because there was no randomness in involving the participants. The subject of the research consisted of two classes of PGMI (Islamic elementary school teacher preparatory program) students who took IPA 2 subject on the topic of Cell Reproduction. The research design is pre-test post-test nonequivalent control group design (Creswell, 2016).

The selection of the classes is based on the equal abilities among them. One class is used as an experimental class consisting of 38 students, and the other class of 35 students as a control group. Both classes use scientific inquiry learning with multimedia on cell reproduction materials. The difference is that the student worksheet given to the Experimental class is given prior to multimedia viewing (Before Watching=BW). In the control class, student worksheet is given after multimedia viewing (After Watching=AW). The learning stages in the study: (1) conducting a pre-test in both classes to determine the initial ability of students; (2) implementing scientific inquiry works on the students worksheet; and (3) implementing post-test in both classes.

The research parameters are learning outcomes obtained from pre-test and post-test in the form of multiple choice questions based on scientific inquiry, while scientific inquiry activities are obtained from the work of the student worksheet during the learning process. Scientific Inquiry in-

dicator refers to what National Research Council (1996) offers, which includes collecting information/data, solving problems, creating variables, formulating hypotheses, graphs/tables, calculating, communicating, predicting and making conclusions. Multimedia is used as a source to explore the data. The assessment on student worksheet used a 0-5 rubric score adapted from the National Research Council (1996) and Popham (2011).

The data were analyzed by using SPSS 17 with  $\alpha = .05$ . The data obtained were averaged, then were described. Pre-test and post-test data from the two subsequent classes were compared with the Independent Sample t-Test. To test the significance of each learning technique, one sample t-test was used (Uyanto, 2009). Data on scientific work activities through student worksheet were analyzed on the basis of their respective indicators offered by National Research Council.

## RESULTS AND DISCUSSIONS

This study obtained the data from pretest and posttest as well as learning outcomes from the two classes with different learning techniques as presented in Table 1.

The table shows that the value of pre-test in the control class (AW) is slightly more varied compared with the experimental class (BW). This is indicated by the standard deviation values of each class on  $sd=6.78$  and  $sd=5.23$ . The difference also occurs in the post-test, which indicated that the students' ability in the control class (AW) is slightly more variable than the experimental class (BW).

**Table 1.** Description of Pretest and Posttest Data Learning Outcomes on Scientific Ability

Description	Pre-Test		Post-Test	
	BW N=38	AW N=35	BW N=38	AW N=35
Mean	55,74	56,23	80,71	78,03
Min	50,00	44,00	72,00	67,00
Max	67,00	67,00	89,00	89,00
St. Dev.	5,23	6,78	4,13	4,97
t-test	P= 0,655>0,05		P=0,15>0,05	

The description on the pre-test and post-test of the experimental class (BW) is presented in Table 2, while in the control class (AW) is presented in Table 3. The data in Table 2 and Table 3 are used to find out the comparison of the learning outcomes based on the teaching method delivered during the lesson.

There was an increase in the learning outcomes of the experimental class (BW) from 55.74 to 80.71 (which improved by 24.97). Increased learning results also occur in the control class (AW) from 56.23 to 78.03 (which improved by 21.8).

**Table 2.** Description of Pretest and Postes Learning Outcomes BW Class

Description	Pretest	Postest	N
Mean	55,74	80,71	Sig 0,00<0,05
Min	50,00	72,00	Berbeda
Max	67,00	89,00	N= 38
St. Dev.	5,23	4,13	

**Table 3.** Description of Pretest and Postest Data of AW Class Learning Outcomes

Description	Pretest	Postest	Note
Mean	56,23	78,03	Sig 0,00<0,05
Min	44,00	67,00	Berbeda
Max	67,00	89,00	N =35
St. Dev.	6,78	4,97	

**Table 4.** Description of the Results of Scientific Work Activities during Learning (Max value=45)

Description	BW	AW	Note
Mean	35,13	32,09	Berbeda
Min	32,00	30,00	
Max	38,00	34,00	
St. Dev.	1,29	1,04	

**Table 5.** Results of Scientific Inquiry Activities during the learning process on the basis of indicators

Indicators	BW	AW	Note
Using Data	4,26	3,09	Different
Formulating Problems	3,00	3,06	Same
Defining Variables	4,47	4,26	Same
Formulating Hypotheses	3,63	3,66	Same
Communicating	4,63	4,60	Same
Creating Images/Tables	4,29	2,71	Different
Calculating	3,71	3,66	Same
Predicting	3,89	3,80	Same
Concluding	3,24	3,26	Same

Data on the results of scientific inquiry activities obtained from the student worksheet during the learning process are presented in Table 4. The assessment was made on the basis of rubric ranging from 0 to 5. The maximum value of scientific inquiry activity is 45. In contrast to the achieved learning outcomes, the results of scientific inquiry activities in

the experimental class (BW) is more diverse than the control class. The data on the diversity of outcomes on the basis of scientific inquiry indicators in the activities are explained and shown in Table 5. The lowest achievements on the scientific inquiry activity are in the experimental class (BW), indicated on the indicator of formulating the problem (3.00) and the highest value is in the indicator of communicating (4.63). For the control class (AW), the lowest result of scientific inquiry activity is on making the image/table (2.71), and the highest indicator is the indicator of communicating.

Based on the objectives of the study, there are three issues that need to be addressed: (1) the comparison between pretest and post-test of learning outcomes in both classes and in each class; (2) comparison of scientific inquiry activities based on learning methods; (3) comparison of scientific inquiry activities based on the respective indicators. Based on the data in Table 1, the pre-test of the experimental class (BW) and control class (AW) were 55.74 and 56.23. The result of statistical analysis on the comparison of pretest between the two classes shows the value of  $p = .655 > .05$ , so there is no statistically difference of the result in the pre-test of both classes. It shows that the initial ability of learning outcomes of both classes is equivalent. Early equal capacity became capital to compare post-test results in both classes (Creswell, 2016: 234). The result of statistic analysis on the post-test concluded at  $p = .15 > .05$ .

The result shows that there is no statistical difference in the result of post-test in both classes. Both classes show the same competition and have the same opportunities in working on the posttest. Although results of post-test in the two classes did not indicate any difference, when reviewing the results of pre-test and post-test in each class, there was a significant improvement in learning outcomes, indicated at  $p = .00 < .05$ . It indicates that during the learning process with the inquiry model, there is a change of learning process, that is the increase of memory activity, motivation and reflexion (Wijaya, 2012). The inquiry learning model encourages students to learn to construct and build their knowledge from their own learning experiences.

The data on the scientific inquiry activities obtained from the student worksheet in Table 4 indicate that different techniques show significantly different results of scientific work activity with the Wilcoxon Test,  $p = .00 < .05$ . The experimental class encountered problems from the student worksheet before using multimedia (BW). The condition of students in BW class was at an advantage in that they have an earlier opportunity to learn the problems first. They have the opportunity to organize and make strategies to solve problems well, have the opportunity to

compile information or data needed more accurately, relevantly, according to the content of the film in the scientific inquiry activity. Inquiry learning encourages students to think critically. Probosari et al. (2012) add that critical thinking is a well-organized mental process and plays a role in the decision-making process to solve problems by analyzing and interpreting data in scientific inquiry activities. In the control class, students obtain student worksheet after the multimedia was used (AW). In this class, students did not have the opportunity to arrange the information as needed, which is accurate, precise, and short according to the content of the film. This lack of opportunity is because students are not challenged to solve the problems they face, so their mental process to organizing does not arise.

Activities to compile data/information and to interpret data become an important part of solving problems in the inquiry activities. Using accurate factual information and interpreting scientific explanations helps students to find a deeper understanding of the natural phenomena they are studying (Harris & Rooks, 2010). The activities of compiling both the data and the information of the two classes are revealed in Table 5. The ability to organize data or use data well and appropriately in the experimental class (BW) is better and significantly different ( $p = .00 < .005$ ) than the control class (AW). This capability has implications on overall scientific inquiry activities (Table 4). In addition to the implications of the results of scientific inquiry activities as a whole, it also implicates the ability to create images/tables. The ability to create reproduction images sexually and asexually in BW class is better and is significantly different ( $p = .00 < .05$ ) than the AW class.

Students' ability to formulate problems; to determine variables; to formulate hypotheses; to communicate; to calculate; to predict and to communicate between two classes equally were examined. The ability of inquiry activities that are not dissimilar to some of the scientific inquiry indicators in the two classes is because the lecturers facilitate the students and provide equal guided opportunities in both classes, allowing them to ask questions about issues they have not understood and later discuss it in pairs. The ability to construct, analyze, and cooperate is important and is necessary for inquiry activities (Harris & Rooks, 2010), to foster responsibility for the tasks/problems facing students. To make changes in the classroom, the lecturer should be involved in the performance, taking part in discussions, brainstorming, practicing, analyzing and reflecting. This not only gives an effect to the progress of student learning but also lecturer as a teacher. In order to facilitate professional growth, lecturers need to make observations and exchange

opinions. It is very important for lecturers to improve the learning quality, especially when lecturers aim to apply innovation in the classroom (Volkinsteine & Namsone, 2016). Based on Table 5 the highest scientific inquiry activities on the inquiry learning in both classes are in communicating. The inquiry learning model encourages many students to perform various scientific inquiry activities. The ability to ask questions, discuss, analyze data and interpret science learning is part of communicating activity. The research conducted by Familiar et al. (2013) in measuring scientific inquiry skills in Biology subject showed the ability to communicate was the second dominant activity (95%) after the activity of understanding of Biology content (100%). The lowest scientific work activity in the BW class is formulating the problem and in the AW class is creating images/tables and formulating the problem. Formulating the problem is the lowest ability in both classes. The assessment rubric for formulating the problem is:

- (5) The problem is expressed in the form of a sentence, the sentence is not double, and it contains the corresponding variable appropriately.
- (4) The problem is expressed in the form of a sentence question, the sentence is not double, and it contains less relevant/exact variables.
- (3) The problems are expressed in a sentence, double sentence, and it contains less related/exact variables.
- (2) The problem is expressed in regular expressions, in the form of multiple sentences, and it has less obvious variables.
- (1) The problems are expressed in regular expressions, multiple sentences, and it does not contain any related variables.
- (0) There are no details of the problem.

Based on the rubric, the student's weakness is to determine the variables associated with the film content. Associating the specified variable in the form of a sentence and a sentence is often found twice. The research finding is the students' learning achievement increased significantly in each class. Different learning methods on the inquiry model do not affect the improvement of student learning outcomes but affect the overall results of students' scientific inquiry activities. The dominant activity in scientific inquiry is communicating. There are two indicators of scientific inquiry that distinguish the results of scientific inquiry activities, namely communicating and creating images/tables. Scientific inquiry activities on these indicators have implications on the overall results of scientific inquiry activities.

## CONCLUSION

The research produces five conclusions. First, inquiry learning with BW technique can improve the result of students' final learning and student's scientific activity. Second, inquiry learning with AW technique can improve students' results on the end of the sessions and student's scientific inquiry activity. Third, different learning techniques do not affect the improvement of students' learning outcomes. Fourth, inquiry learning produces the dominant scientific inquiry activity, which is communicating. Fifth, activities employing the use of data have implications on the overall results of scientific inquiry activities and affect the activity of making images/tables.

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**THE PERCEPTIONS OF PRE-SERVICE SCIENCE TEACHERS  
AND SCIENCE TEACHERS ABOUT CLIMATE CHANGE****Meilinda<sup>1,2\*</sup>, N. Y. Rustaman<sup>2</sup>, B. Tjasyono<sup>3</sup>**<sup>1</sup>Department of Biology Education, Faculty of Teacher Training and Science Education, Universitas Sriwijaya, Indonesia<sup>2</sup>Departement Science Education, Postgraduate School, Universitas Pendidikan Indonesia, Indonesia<sup>3</sup>Department of Meteorology, Faculty of Earth Technology dan Science, Institut Teknologi Bandung, Indonesia**DOI: 10.15294/jpii.v6i2.9490**Accepted: February 18<sup>th</sup>, 2017. Approved: June 30<sup>th</sup>, 2017. Published: October 17<sup>th</sup>, 2017.**ABSTRACT**

The global climate phenomenon in the context of climate change is the impact of both the dynamic complex climate system and human behaviors that affect environmental sustainability. Human is an important component that should be considered in science teaching that is believed to improve human attitudes towards the environmental sustainability. The research aims to investigate the perceptions of pre-service science teachers and science teachers in South Sumatra who teach climate change and global warming. The data were collected from 17 science teachers and 53 pre-service science teachers from April to August 2016. The instruments were 17 modified questions which were developed from Pruneau's framework. There are three linear perceptions regarding climate change. First, greenhouse effect causes global warming and global warming causes climate change. Second, ozone leakage causes global warming and global warming causes acid rain. Third, greenhouse effect causes ozone leakage and ozone leakage causes global warming; then it causes climate change and other climatic phenomena. Both pre-service science teachers and science teachers argue that climate change is caused by global warming. Actually, climate change is not only global warming but also global cooling. Those phenomena occur because of interactions among climate system components. They do not believe that education is able to change human attitudes in saving environmental sustainability from global climate change disasters. They believe that media give stronger effects than teachers in shaping those perceptions. Factually, most of wrong perceptions come from media.

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**Keywords:** global warming; climate change; perception**INTRODUCTION**

Education has a positive impact on students' attitudes; one of them is attitude towards the environment. The most important issue of the environment is climate change. Because of that, it becomes part of climate literacy education for all ages, especially for K-16 and adults (Nam & Ito, 2011). In Indonesia, environmental materials such as global warming and climate change are in integrated science classes (at lower secondary schools) and separated science classes (at upper

secondary schools) in different portions and purposes.

Climate change is an important issue because it has a great deal of impacts on the environment, human health, crop productivity, even extinction of the world's living population. However, some people believe that climate change has no impacts on their lives (Pruneau et al., 2001). They believe that humans will be able to survive and adapt from global warming and climate change if they have technology (Shepardson et al., 2012; Tran et al., 2010; Porter et al., 2012). The results of academic surveys in the United States show that people do not reduce their activities of using motor vehicles, air condi-

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tioning, and heating in excess although many of them are concerned about climate change (Nam & Ito, 2011; Leiserowitz, 2006). Indonesia is one of the top four countries that contribute to environmental damage after Brazil, USA, and China (Bradshaw et al., 2010). The purpose of science education in Indonesia is to show wise and responsible behaviors in daily activities such as using energy economically and not harming the environment. Indonesian behaviors that are inconsistent with the purpose of science education are due to the low level of students' understanding of environmental problems contextually. Students' cognitive understanding is influenced by the structure and distribution of the curriculum, the presentation of learning materials, and the cognitive understanding of teachers and prospective teachers (Widiyanti et al., 2015; Fakhriyah et al., 2017); and students' cognitive understanding of the environment influences students' attitudes towards the environment (Courtenay-Hall & Rogers, 2002; Yunus, & Sanjaya, 2013).

Global warming and climate change have a small portion in KTSP science curriculum for lower secondary schools with regards to the topic of environmental problems and pollution. In 2010, global warming and climate change were discussed more on 32 electronic books for teachers and students of lower secondary schools. The portion of these contents is 37% in the seventh graders' books, 12% in the eighth graders' books, and 86 % in the ninth graders' books. The discussion is spread in several topics such as air pollution, earth processes, technological impacts, and life impacts on the lithosphere. In the 2013 curriculum, the issues of global warming and climate change are in the seventh grade of the lower secondary schools. It is at the basic competence of 3.10, which reads: "describes global warming and its impacts on the ecosystem after discussing the concepts of energy, the interaction of living things, and environmental contamination." Besides, global warming and climate change are part of the fourth core competence for the seventh graders. It is at the basic competence of 4.13, which reads: "presents data and information regarding global warming and gives solution to the previous problem of global warming and climate change." The topics on the previous basic competence are photosynthesis and respiration, heat and temperature changes as well as heat propagation, and humans' interaction with their environment. Those topics will not be linked with global warming and climate change. Factually, students do not realize that climate occurs due to intercomponent interactions on earth, solar, and human sys-

tem. This condition is believed to be the impacts of structure and distribution of curriculum.

Teachers' problem is the lack preparation of environmental knowledge contents and interconnection of those contents with others. When teachers assume environmental destruction as a simple content that is restricted to the context and its solution, they will only deliver it without linking the content with others. It shapes students' perception that environmental destruction content is only a memorization concept. Students do not see the concept as a real and contextual problem that threatens their future lives (Mostafa, 2007).

Related research about students' perceptions of global warming was conducted by Kalo, E. L., & Simatupang Z. (2016) at upper secondary schools in Medan, Indonesia. The result shows that students have low knowledge of global warming (<50%). Before implementing 2010 curriculum, the British council conducted a study on the perception of climate change in Indonesia (Marwan & Sweeny, 2010). Previous research also shows that 42% students and 65 % of teachers agree that climate change is caused by nature and human treatment. They are 2.234 teachers and students of primary and lower secondary schools in four provinces of Indonesia (Yogyakarta, East Java, East Borneo, and Papua). Most of them believe that ozone depletion is a major cause of climate change besides pollution. Both teachers and students believe that climate change could be prevented by planting trees. It decreases global surface temperature. National Development Planning Agency recommends climate change as a content of science education in Indonesia (Triastuti et al., 2009). Unfortunately, climate change is delivered as a separated subject in a variety of subjects, especially science, geography, and local content.

This research presents the perception of science teachers and pre-service science teachers in South Sumatra after collaborating global warming and climate change content into the science curriculum for both lower and upper secondary schools. Their perceptions and understandings will be positively correlated to the concerns, attitudes, and behaviors of the students as golden future leaders.

## METHODS

The study involved 17 science teachers in one of the teachers' discussion forums in South Sumatra and 53 students of Mathematics and Natural Sciences Education Faculty at one of uni-

versities in South Sumatera. They were students at the 6<sup>th</sup> semester. They were selected by using purposive sampling. There were several reasons regarding the sampling selection. First, science teachers of lower secondary schools could teach content with an emphasis on science literacy. Second, students of the 6th semester have taken the human and environmental course and environmental chemistry course. Data were collected from May to July 2016 by using an instrument that was developed from Pruneau et al. (2001). It consisted of 17 questions about global warming and climate change context information sources, the relationship between global warming and climate change, and the causes of climate change based on the climate change theory. The data were analyzed, percented, and interpreted descriptively, then compared with the previous similar results that have been revealed elsewhere.

## RESULTS AND DISCUSSION

### Information on Global Warming and Climate Change

Based on the questionnaire, some initial data related to the global phenomena of global warming and climate change were found. The data are as follows:

**Table 1.** Information on Global Warming and Climate Change

Global Phenomena	Pre-Service Teacher (%)	Teachers (%)
Global Warming	100	100
Climate Change	100	100

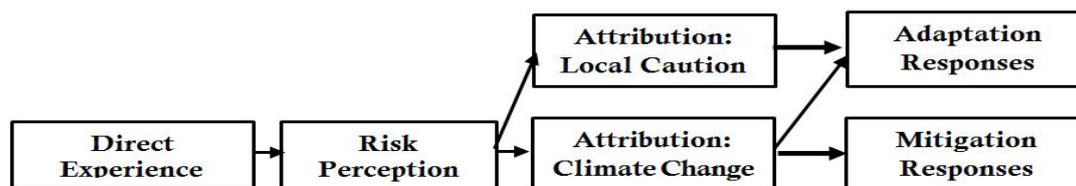
Table 1 shows that both teachers and pre-service teachers have heard of both climate change and global warming phenomena. Teachers and pre-service teachers (100%) get information about climate change and global warming mostly from mass media such as TV broadcasts, newspapers, magazines and internet, such as blog and Wikipedia (75%). Furthermore, the remaining teachers in the class (51%) get the information from

textbooks, friends, and books (36%, 16%, 6%). The small amount of information obtained from textbooks is estimated because the materials regarding global warming and climate change have just been included formally in the school-based curriculum (Syafri, 2008).

Teachers and pre-service teachers believe that global warming and climate change influence their social life (100%) in the form of hot and erratic weather, health, water difficulty, and even emotional level. There are 45% of pre-service teachers and teachers who started thinking about global warming disasters and climate change events after extreme weather events in their neighborhoods, while some teachers (10%) and pre-service teachers state that they like the current weather conditions.

Teachers and pre-service science teachers believed that climate change and global warming impacted on their social life (100%). They caused weather anomalies, health problems, water difficulty, and even emotional level disorder. There were 45% of teachers and pre-service teachers started thinking about disaster that was caused by climate change and global warming. It was because of the extreme weather that has been occurred. Whereas, 10% teachers and pre-service teachers did not think about this case because they loved the current weather condition. The impact of climate change and global warming is a serious concern among people in 34 countries, but it does not necessarily change their lifestyles (Bedford, 2004). Both of problems are not the daily faced issues like terrorists, health or economic problems, so they affect nothing to people's lifestyles (Krosnick et al., 2006). Lifestyle will change when people have direct experiences or the perception of a disaster (Bord et al., 2000; Helgeson et al., 2012). This can be seen on Figure 1.

This is similar with a research that is conducted by Spence et al. (2011) about the flood that encourage the population of a region in the UK to reduce the energy from fossil fuels in their environment significantly. The fossil fuels combustion produces carbon dioxide.



**Figure 1.** Experience, Perception & Attribution of Risk

### Perceptions on The Relationship between Global Warming and Climate Change

Teachers' and pre-service teachers' perceptions on the relationship between global warming and climate change can be seen in Table 2.

**Table 2.** Perceptions about The Relationship between Global Warming and Climate Change

Teacher	Pre-Service Teacher	%
	Global warming is the cause of climate change.	54
The increasing temperature indicates global warming as climate change increases.	Global Warming and Climate Change cause the effects of Green House Gases and acid rain.	30
	Global warming is tantamount to climate change.	16

All teachers in the sample of this study understand that global warming influences climate change. From further interviews, it is found that teachers equate climate with weather so that climate change is considered as weather change. In other words, the higher the earth's surface temperature gets, the greater the weather changes occur. Weather is defined as the state of the atmosphere in a certain place and time. Weather is usually expressed in terms of temperature, air pressure, humidity, wind speed and direction, rainfall, and turbidity. Meanwhile, climate is defined in terms of average (mean) of weather elements (such as temperature and rainfall) over a period of time (30 years) (Tjasyono, 2006). This perception is also owned by 54% of the pre-service teachers.

According to Table 2, the second pattern of the pre-service teachers is the perception that climate change and global warming are caused by the effects of green house gas and ozone holes. This perception arises because they consider that the dominant green house effect caused by CO<sub>2</sub> arises from human activities. Activities such as forest burning, fossil fuel use, factory smoke and so on produce CO<sub>2</sub>, which then binds with ozone in the atmosphere so that the ozone decomposes and punctures. Perforated ozone, according to the perception of the pre-service teachers, can increase the intensity of solar radiation entering the earth's surface so that the temperature increases and then global warming occurs (30%). This perception has three patterns: (A) Green house effect causes global warming, which leads to climate change; (B) The perforated ozone causes global warming and climate change; (C) Green house

effect causes ozone holes and ozone holes cause global warming, and global warming causes climate change and other climatic phenomena.

This perception is similar to what was found in the pre-service teachers and students in America (Khalid, 2003; Daniel et al., 2004) science teachers and students in Turkey (Pekel & A-zay, 2005; Kılınc, 2008), communities in Norway (Ryghaug et al., 2011) and in Canada (Pruneau et al., 2001). Based on further interviews, this perception arises because the students believe that CO<sub>2</sub> will decompose to become C and O<sub>2</sub> in the atmosphere. Carbon from CO<sub>2</sub> will then bind with O<sub>3</sub> in the atmosphere so that O<sub>3</sub> becomes biodegradable and results in ozone perforation. In further interviews, according to the pre-service teachers' perceptions, not only does CO<sub>2</sub> decompose while it is in the atmosphere, but H<sub>2</sub>O also becomes H<sub>2</sub> and O. According to them, H<sub>2</sub> and O will regroup into clouds so that it will not disrupt the ozone layer in the atmosphere. Those perceptions arise because students believe that the only cause of global warming and climate change is the CO<sub>2</sub> produced by human activities. Most of these perceptions arise from mass media sources and textbooks in schools (Choi et al., 2010).

### Perceptions on The Causes of Climate Change

Climate change based on the existing theory is influenced by several factors such as the movement of continents in geological time, the sun, volcanic eruption, and CO<sub>2</sub> as the impact of human activities (Karl, 2003; Tjasyono, 1986). Based on the data, 100% of teachers and pre-service teachers perceive that humans are the only factor causing climate change. This has led to the answer to the questionnaires about the impact of volcanic eruptions on climate being largely unpredictable weather changes (65% of teachers, 64% of pre-service teachers). Nevertheless, 20% of students admitted that they did not know the effect of volcanic eruptions on climate, while the rest perceived that volcanic eruptions could cause a global rise in the temperature of the earth. According to the pre-service teachers and teachers, the causes of climate change in general are air pollution (72% and 65%) and ozone layer depletion (36% and 35%); and one person perceived that climate change is caused by the rotation of the earth due to the interaction of the earth with the sun.

Volcanic eruption releases lava from the lithosphere inner layer (geosphere). It forms rocks on the surface of the earth as well as spraying particles of gas and dust into the atmosphere layer. The gas and dust entering the atmosphere will

continue to enter the stratosphere and affect the climate system (Solomon et al., 2011). The dust from volcanic eruptions entering the stratosphere will prevent the entry of solar radiation to the earth's surface and will have an impact on global cooling (Rampino et al., 1979). Most teachers and pre-service teachers misunderstand the effects of eruption on climate change because this material does not deliver in junior high school and senior high school even in Biology or Physics education program. This is similar to research findings that was conducted in Canada by Pruneau et al. (2001).

### Actions to Climate Change

Based on Table 1, 100% of teachers and pre-service teachers have heard about global warming and climate change. They are worried about the phenomenon, especially after the occurrence of extreme events in their region (81%). According to teachers (41%), the most likely action to slow climate change is to educate people about the importance of caring about issues of global warming and climate change. According to pre-service teachers of chemistry education, the most likely action to slow climate change is by reducing pollution and recycling. Meanwhile, the pre-service teachers majoring in Biology suggest that climate change be slowed by planting trees. This difference is thought to be influenced by their scientific backgrounds. Although teachers and pre-service teachers believe that educating people about environmental issues can be done to slow climate change (35%), but they tend to believe media information than others.

### CONCLUSION

The conclusion of the study is that more than 50% of science teachers and pre-service science teachers have a false conception of global phenomena such as global warming, climate change, ozone depletion, and acid rain. Some science teachers and pre-service science teachers view that global warming is the cause of climate change caused by ozone depletion and although they are the main actor of education, they have no belief that education can change human behaviors in facing the global climate phenomenon and they believe that, instead, media can do it better.

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**CAPTURING THE PCK ABILITY OF PROSPECTIVE SCIENCE TEACHERS USING CoRe AND PaP-eR****S. Nurmatin\*<sup>1</sup>, W. Purwianingsih<sup>2</sup>**<sup>1</sup>Department of MI Teacher Education, Sekolah Tinggi Agama Islam Tasikmalaya, Indonesia<sup>2</sup>Department of Biology Education, Universitas Pendidikan Indonesia, Indonesia

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Accepted: April 19<sup>th</sup>, 2017. Approved: July 18<sup>th</sup>, 2017. Published: October 17<sup>th</sup>, 2017.**ABSTRACT**

This study involving prospective science teachers at SMP aims to portray the ability of Pedagogical Content Knowledge (PCK) of the teachers via resource folios. Resource folios in question are the core and PaP-eRs made by the prospective science teachers when carrying out the “Program Pengalaman Lapangan” (PPL). The subjects were six candidates conducting PPL at a junior high school and were assigned by the class teachers to teach Grade VII. The instrument used as a means of collecting data in this research is the CoRe and PaP-eRs. The instrument has been analyzed using an analytical format. The result of CoRe and PaP-eRs analysis shows that the learning activities are carried out on the whole in accordance with lesson plans that have been rendered previously. However, the instruction plan is focused more on the CoRe content materials to be studied, while the narrative of learning implementation in the PaP-eRs is emphasized more on learning activities. The results show that the PCK ability of prospective teachers still do not show the integration between content capability and pedagogical ability.

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**Keywords:** pedagogical; CoRe; PaP-eRs**INTRODUCTION**

The results of several studies assumed that in order to implement the teaching practice, a teacher needs some knowledge that underlies his teaching activities (Brown et al., 2013; Hanuscin, 2013; Seung, 2013; Seung et al., 2012). In other words, becoming a teacher requires a basic knowledge to carry out learning. The basic knowledge that teachers need to have is focused on developing teacher knowledge in learning that is divided into three knowledge groups: pedagogical knowledge, knowledge of learning content and knowledge that integrates content with pedagogy (Gess-Newsome et al., 2017; Seung, 2013; Seung et al., 2012). Of the three basic knowledge, the most important knowledge possessed by teachers is the knowledge that integrates material content

with pedagogy (Anwar et al., 2013; Aydeniz & Kirbulut, 2014; Nilsson, 2014; Seung, 2013). The knowledge that integrates content knowledge with pedagogy, by Shulman (1987), is called Pedagogical Content Knowledge (PCK).

Pedagogical Content Knowledge (PCK) was first introduced by Shulman (1987) as a major component of learning, emphasizing that learning is not just knowledge of material content but learning is an integration of content knowledge with pedagogical knowledge (Brown et al., 2013 ; Donnelly & Hume, 2015; Hanuscin, 2013; Rich, 2009; Nilsson & Loughran, 2012). In Hanuscin (2013), Shulman argues that PCK is a fundamental component of the knowledge base for teaching. Others argue that PCK is part of an academic building that shows interesting ideas related to what and how to teach (Iserbyt et al., 2017; Sagır & Küçükaydın, 2016). From these statements, the authors argue that PCK is an

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integration of knowledge content with pedagogy that serve as the basis for carrying out learning. Currently every learning process in Indonesia is managed by the government.

In the Ministerial Regulation No. 65 of 2013, the government directs the learning process to include three domains, namely, attitudes, knowledge, and skills. To create the learning process as expected in the Ministerial Regulation No. 65 of 2013, the government regulates the competencies that must be owned by teachers. Competencies that must be owned by teachers are listed in the Ministerial Regulation No. 65 of 2013; they are pedagogy competence, personality competence, social competence, and professional competence. Two of the five competencies listed in the Ministerial Regulation No. 16 of 2007 having an important role in the learning activities are pedagogical competence and professional competence. Pedagogy competence includes teacher ability in understanding learning and teaching theories and everything related to learners, whereas professional competence includes teacher ability in understanding subject matter. Therefore, pedagogy competence and professional competence are parallel to PCK ability which is disclosed by Nilsson & Vikström (2015); that is, PCK is the knowledge of integrating the subject matter knowledge and pedagogical knowledge. Based on Government Regulation and expert research results, it can be argued that every teacher needs to have PCK ability to carry out his learning.

A teacher will have good PCK skills if his skill is developed from the time of his education to become a teacher, he can be called a prospective teacher. In line with the rules stating that a prospective teacher should not only demonstrate knowledge and teaching skills in order to achieve the learning objectives, but he must demonstrate knowledge in determining learning strategies that can involve learners. Field findings based on the questionnaires to several prospective teachers indicates that the learning process can be used for learning activities. However, prospective teachers do not show how to teach a particular concept to be accepted by learners. Overall, based on the questionnaire, the teacher candidates revealed that the most important thing in learning is the interaction between teachers and students. This is in accordance with the results of previous studies which reveal that prospective teachers are unaware of the involvement of pedagogy and the act of facilitating students in a lesson (Hume & Berry, 2011). Due to the importance of PCK skills of

prospective teachers, it is necessary to analyze the PCK ability of prospective teachers.

The PCK ability of prospective teacher can be introduced in some courses related to the education of a lesson, and it will be more noticeable when prospective teachers follow the Field Experience Program (Wahyuni, 2015). Tools that can be used to analyze the PCK ability of prospective teacher are Content Representation (CoRe) and Pedagogical and Professional Experience Repositories (PaP-eRs). CoRe and PaP-eRs are resource folios used to capture the PCK ability of teacher and prospective teacher as they explicitly demonstrate the relationship between content knowledge and teaching and learning skills of science teachers and prospective science teachers (Hume & Berry, 2011; Sagır & Küçükaydın, 2016).

CoRe is a format composed of rows and columns. The highest row shows the main topic, followed by the main idea which represents the main topic (Bertram & Loughran, 2012). Columns in the CoRe format are composed of two, that is, the right column and the left column. The left column is comprised of eight questions related to content knowledge and pedagogy knowledge, while the right column shows answers from prospective teachers based on the main idea predetermined (Loughran et al., 2012). Based on expert opinions about CoRe, it can be said that CoRe can be used to capture the PCK ability of prospective teachers. The other CoRe, the other element that is used to capture the PCK ability is PaP-eRs.

PaP-eRs is a narration from learning implementation which highlights aspects of the subject matter being taught (Loughran et al., 2012). PaP-eRs highlights learning that has planning and activities like student responses, interaction between students and learning media, and the result of student learning assessment. From expert opinions, it can be said that CoRe and PaP-eRs can integrate subject matter knowledge with pedagogical knowledge of prospective teachers ranging from planning to implementation of learning. Therefore, based on the above description related to the basic knowledge that must be possessed by teacher candidates, that is, knowledge that integrates content and pedagogy (PCK), the authors conduct research that analyzes the PCK ability of prospective teachers by using CoRe and PaP-eRs. This study aims to capture the ability of prospective teachers in planning and implementing learning in the classroom through resource folios.

**METHODS**

Two junior high schools in Bandung serve as a place of research by involving six prospective teachers conducting teaching practice through “PPL” at the said schools as research subjects. Prospective teachers who serve as research subjects are prospective teachers assigned by the class teachers at the schools to teach the seventh graders. The research method used is qualitative, that is, one that does not give treatment in implementation (Creswell, 2012). The research describes the ability of prospective teachers in integrating subject matter knowledge with pedagogy knowledge through CoRe and PaP-eRs of the same content. The study began by studying the curriculum used at the chosen schools where prospective teachers conducted the “PPL”. After a review of curriculum, the prospective teachers were required to fill in the CoRe as part of lesson planning. Then, after carrying out learning, the prospective teachers were requested to reflect on learning through the making of a narrative called PaP-eRs. Each prospective teacher’s implementation of learning was recorded by video. The video was used by the prospective teachers to make learning reflection (PaP-eRs). CoRe and PaP-eRs made by the prospective teachers were next analyzed using format analysis.

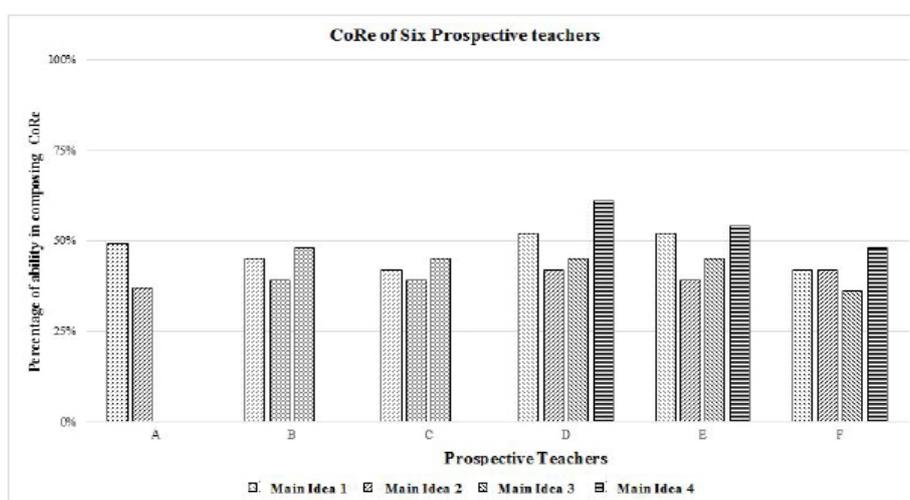
**RESULTS AND DISCUSSION**

Capturing the PCK ability of teachers or prospective teachers is indicated by resource folios consisting of two elements, that is, CoRe and PaP-eRs (Loughran et al., 2012). CoRe is a

format used in representing content and capturing the PCK ability of prospective teachers when planning a lesson (Nilsson & Loughran, 2012; Nurmatin & Rustaman, 2015). PaP-eRs is a supporting document. CoRe shapes the narrative of a teacher’s teaching experience by underlining certain parts of learning implementation or aspects of the material taught. The CoRe is filled by the prospective teachers before implementing learning, while PaP-eRs is created by the prospective teachers after implementing learning.

The PCK ability of six prospective teachers in the planning of learning is shown through CoRe. The PCK ability in planning the lesson shown through the correspondence between the main idea of matter and ability to elaborate every main idea according to eleven components in the CoRe. The eleven components in the CoRe are in the form of questions. These eleven questions represent the knowledge of the prospective teachers related to the concept that must be understood by students. The ability of students to accept the concept, the learning process that will be implemented up to the way the students are assessed are related to the main idea that emerges. The percentage of PCK ability of the prospective teachers on the basis of their ability in composing CoRe is shown in Figure 1.

Figure 1 shows that the mean score of PCK ability of six prospective teachers is under 50% with the number of ideas raised by each prospective teacher being different. The number of main ideas is not specified specifically for a particular material (Loughran et al., 2012). Therefore, prospective teachers have freedom in determining the number of main ideas from a particular material.



**Figure 1.** PCK Ability in Composing CoRe

The number of main ideas determined by the prospective teachers starts from two up to four main ideas. The main idea illustrates the ability of the prospective teachers in determining the important concept that develops students' understanding (Loughran et al., 2012). Prospective teacher A writes just two main ideas; prospective teachers B and C write three main ideas each, while prospective teachers D, E, and F write four main ideas each. Overall, though the number of main ideas shown is different, the overall content of main ideas from six prospective teachers is the same.

However, three from six prospective teachers, namely, prospective teachers A, B, and C have not been able to write down the right idea in the concept. If the prospective teachers have not understood the concept, the prospective teachers have not described the concept to be accepted by students (Etkina, 2010). Therefore, prospective teachers A, B, and C have not been able to write main ideas correctly in the concept; they have not been able to translate a concept to be accepted by students. Based on Figure 1, evenly the main idea that has a low percentage is the second main idea. It happens because the six prospective teachers have difficulty especially in elaborating the initial concept that will affect the learning of the second main idea.

Furthermore, any predefined underlying idea is elaborated on the basis of the eleven components contained in the CoRe. The eleven com-

ponents contained within CoRe should describe lesson planning to the main idea that has been specified. However, the prospective teachers' ability in describing the eleven components has not shown that yet. The ability shown by the prospective teachers in describing the eleven components of CoRe is just answering questions from the eleven components. This is especially in outlining the four components of CoRe related to material constraints, predictions of difficulty in teaching, early knowledge of students that may affect learning, and how to assess students.

Based on the result of the analysis of CoRe of six prospective teachers, the result obtained reveals that the ability of prospective teachers in the PCK planning of learning through CoRe has not shown the ability to integrate content knowledge and pedagogy. In addition to CoRe, the ability of prospective teachers in PCK is captured by making the narrative after the learning of PaP-eRs.

PaP-eRs created by the prospective teachers in the form of narrative is based on learning that has been done by the prospective teachers. The prospective teachers create the PaP-eRs based on the video recording of the implementation of learning so that every implementation of learning is reflected. But in reality it is not the case. In reality three prospective teachers create PaP-eRs based only on memory, so the result is a narrative on learning in outlines only. The ability of prospective teachers in creating PaP-eRs is shown in Figure 2.

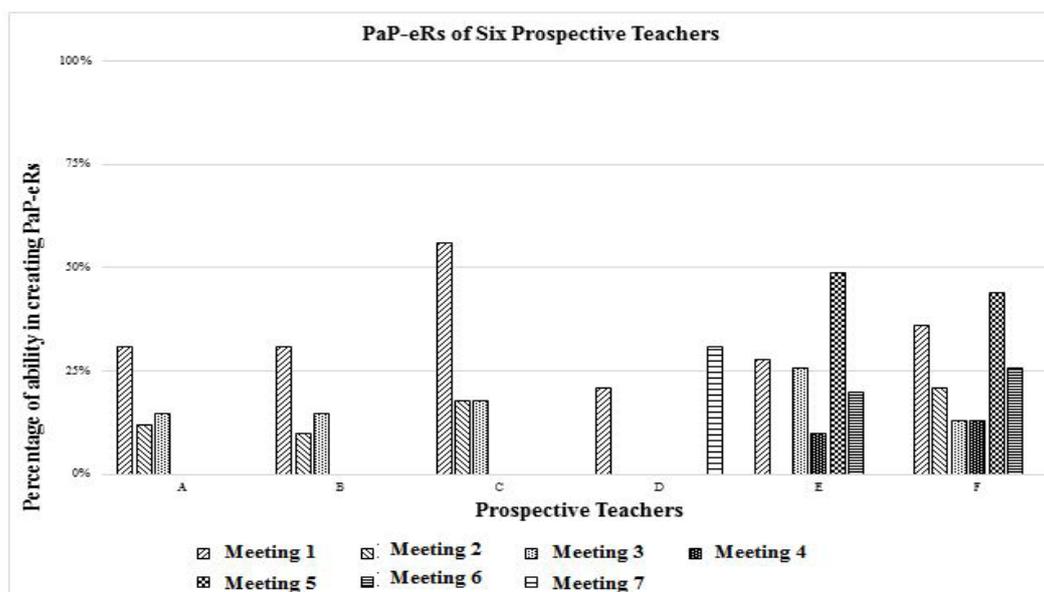


Figure 2. Ability of Prospective Teachers in Creating PaP-eRs

Figure 2 shows that five from six prospective teachers create PaP-eRs according to the number of learning meetings conducted, while one of them creates only two PaP-eRs from seven meetings of learning. However, the number of PaP-eRs made does not affect the result of the PaP-eRs analysis as a representation of the ability to reflect on learning. The ability of reflecting is part of the PCK ability of prospective teachers analyzed based on the content of PaP-eRs created by the prospective teachers. Overall, based on Figure 2, the ability of six prospective teachers in narrating the implementation of learning is still below 50%. This shows that the prospective teachers have not been able to reflect on the whole learning in terms of its aspects.

Six prospective teachers create PaP-eRs with the narration of the implementation of learning covering introduction, core, and closing activities. In core activities, six prospective teachers do not overall narrate the learning that is implemented, so the narrative cannot be used as a reflection in learning. Actually the purpose of making PaP-eRs is to elaborate and provide insight into the interaction between students and teachers so that it can serve as a reflection of learning (Loughran et al., 2012; Mulhall et al., 2003). Therefore, the result of the analysis of six prospective teachers' ability in reflecting on learning through the creation of PaP-eRs has not demonstrated their ability of PCK to integrate content knowledge and pedagogy.

The result of the analysis of resource folios consisting of CoRe and PaP-eRs during the study shows that six prospective teachers already have content knowledge and pedagogy knowledge, but they are not yet integrated as a whole. The ability to integrate content knowledge with pedagogical knowledge is not yet fully owned by the prospective teachers so that the planning and reflection of learning has not shown the ability of PCK intact. The ability of PCK has not appeared fully because the experience of the six prospective teachers is still minimal.

## CONCLUSION

Based on the result of the analysis of resource folios, the PCK ability of prospective teachers A, B, C, D, E, and F does not show PCK ability intact. This is demonstrated by CoRe and PaP-eRs that have been made by the six prospective teachers during the study. In creating CoRe, six prospective teachers do not show the ability to integrate content knowledge with pedagogy knowledge. The description of each component of

CoRe is limited to answering questions alone. It is not used as a tool for planning learning so that it is only more content knowledge. Meanwhile, the narrative of learning (PaP-eRs) created by six prospective teachers after implementing learning cannot be used as a reflection of learning. The PaP-eRs created by the six prospective teachers brings up the ability in pedagogy more. Thus, it can be concluded that the ability of PCK of prospective teachers A, B, C, D, E, and F in planning and reflecting learning is still minimal. The lack of potential of A, B, C, D, E, and F teachers' skills is indicated by the unintegrated knowledge of the content and pedagogical knowledge they have in the CoRe and PaP-eRs that have been made.

The PCK ability of the prospective teachers is not an ability to be trained within a short period of time. "Program pengalaman lapangan" (PPL) cannot assure that the PCK ability of prospective teachers can develop well. Therefore, for further research it would be better if there is a continuous program related to PCK so that the ability of prospective teachers is more honed; and it would be better if the program is in the lecture.

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## PERFORMANCE ANALYSIS OF POWER BANK FITTED WITH RECYCLED LAPTOP BATTERIES

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### ABSTRACT

The result of observation at Science Laboratory of State Vocational High School 3 of Surakarta shows that the power capacity of power bank fitted with recycled laptop batteries was not tested. Power bank test was conducted by preparing used laptop batteries type 18650 from its packaging for a total of five cells, selecting batteries based on their physical appearance, cleaning the pole connections, testing the voltage, testing temperature when power charging from electric outlet to power bank, testing the power drain, testing the power capacity without load, charging in the case, testing the module when power charging from electric outlet to power bank, testing the power capacity level indicator, testing power charging from power bank to recharged device, installing the power bank analyzer, and recording voltage measurement results, electric current flowing, duration of time needed to charge, and power capacity left after charging. The electric load used was a 1.2 watt LED lamp. After that, the calculation of battery power capacity was conducted, in accordance with the technical specification listed in the power, then compared to the result of test of power capacity stored in recycled power bank. Based on the result of technical specification calculation, the power bank produced had a power capacity of 50.000 watt hours. Meanwhile, in the experiment with LED lamp electric load, the power bank had a power capacity of 44.6756 watt hours. The comparison of power capacity between the technical specification and the experiment shows that the recycled power bank had performance of 89.4%. Thus, recycled power bank met the requirement of feasibility to be learning media of physics project.

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**Keywords:** work method; power bank; recycling; laptop batteries

### INTRODUCTION

The word conservation is defined as a process of regular maintenance and protection to prevent damage, by way of preservation. Conservation can be interpreted as an act of doing protection and/or preservation, to preserve something from damage, destruction, loss, or else (Margareta et al. 2011). Dangerous and toxic material wastes can threaten the sustainability of environment. Conservation is a way to preserve environment, while still paying attention to possibly gained benefits at the certain time by keeping the

existence of each component of the environment for future use. These wastes should be managed well so that they will not threaten the present and future generation (Suhadi, 2012). To decrease the environmental impact, lithium-ion portable batteries can be recycled with its volume expected to increase by a third from 2013 to 2017 (Boyden, S. & Doolan, 2016).

Lithium-ion batteries are the most common battery type used in portable electronic devices and their use is expected to double from 2013-2014 to 2019-2020. The recycling of lithium-ion batteries reduces energy consumption, reduces greenhouse gas emissions, and results in considerable natural resource savings when compared

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to landfill. However, it is unclear which recycling processes have the least impact on the environment. This paper will investigate the different processes that are currently used for recycling portable lithium-ion batteries, such as hydrometallurgy, pyrometallurgy, and combinations of processes. Surveys are carried out to understand the materials recovered from each process, and are obtained from several recycling companies around the world. A comparative life cycle assessment will be performed for two different recycling processes (hydrometallurgy and pyrometallurgy, by decreasing the mileage between collection and recycling).

One of the conservation efforts conducted is laptop battery recycle to power bank product. In this research, the most effective model was developed for system of interaction analysis between physical process and information stream, short-term and long-term effects to the environment from the portable battery waste (Blumberga et al., 2015). The developed model is important to be an input for policy makers on policy evaluation, collection, and steps.

The high number of gadget users is also followed by the increase of battery-dependent daily activities. A research places Indonesia on the top 5 gadget user in number, with 47 million of active users, or approximately 14% of overall number of gadget users in the world (Gifary, 2015). Other research shows that younger generation in Indonesia who have a high degree of education tend to use mobile internet, especially from smartphones (Puspitasari & Ishii, 2016). Meanwhile, personal computer is used for large-scale data management in information gathering in daily life. This finding also shows the importance of ICT education and the prospects of mobile internet segment in order to fill the digital gap with developing countries.

The growing number of gadget-dependent activities directly impacts to the growing number of consumption of battery energy. Battery is a part of gadget with the most rapid damage rate, yet it can still be recycled. The battery age can be estimated and investigated to find more optimal next generation batteries (Kalmykova et al., 2017).

A power bank is a device used to insert electrical energy to a rechargeable battery, without having to connect the device to electrical outlet. It can be used without having to connect it to an electrical device. It has electrical capacity so that when the energy contained in the power bank has been depleted, the power bank must be recharged by connecting it to an electrical outlet. It is mostly used to recharge gadget batteries. It

is used by connecting the device connector cable to the portable battery charger. The connector cable connecting the device with the power bank is called USB connector, which is connected to the other end which is shaped like the customized device charger. There are some weaknesses in fast mode power bank battery charging, on the balance of charging time with the excessive raise of battery temperature (Zhang et al., 2017).

Portable battery device always develops from time to time, in its type of use, capacity, and energy density (Pistoia, 2009). The main component which constitutes a power bank is battery. There are also other components, namely: (1) lithium-ion rechargeable battery type 18650 which functions as energy storage which transforms chemical energy stored into electricity. It is like power bank module, which is an array of electronic device functioning to control electrical current flow when charging power from electric outlet to power bank and when charging power from power bank to recharged device (Schmalstieg et al., 2014); (2) LED indicator which functions to inform battery level at the time of power charging from electric outlet to power bank and power charging from power bank to recharged device; (3) Casing which functions as a storage place of power bank devices; (4) Port which functions as an in/out outlet at the time of entry and power charging from power bank to recharged device; and (5) connector, which is a cable connecting the charger to power bank or power bank to the recharged device. After assembly process, a set of recycled battery, module, battery charger level indicator, port, and connector cable will be used as a set of integrated instruments for project-based learning of Physics.

The level of motivation of students in Science learning is much better through battery project-based advance organizer learning model (Tasiwan et al., 2014). Project-based learning gives a limited illustration for big things which can form soft skills of conservation (Pavaloiu et al., 2015). There are five soft skills of conservation, namely love for environment, environmental consciousness, responsibility, objectivity, and honesty (Rosita & Marwoto, 2014). It is hoped that through cooperative model, the learning conducted can encourage students to learn more and work in groups related to certain courses. It is also expected that they will try to achieve the project goal synergically and will be much more ready for future work and technical competence. Lastly, it is expected that the students are able to use technology by correct and efficient means in product design, to understand new technolo-

gies, or to solve problems related to mechanism during product development and to build general discourse through various disciplines to comprehend the new technologies, to solve mechanism problems during product development and to establish a common discourse with other engineers during multidisciplinary work (Zadeh & Satir, 2015). This study focuses on the content of physics and related classes that belong to the curriculum of Industrial Product Design Department (IPDD). The main material taught was direct current (DC), with an emphasis to recycled laptop battery products. Power capacity is the amount of energy stored in a battery, indicated by *miliAmpere hours* (mAh) (Ecker et al., 2014)

Based on the background of problems above, this research is focused on how to test the performance of power bank fitted with recycled laptop batteries if reviewed from power capacity as shown in specifications and power capacity proven through experimentation.

## METHODS

This research used descriptive research type, by describing the performance of produced integrated instrument tools from recycled laptop batteries, which would be used for project-based learning in school laboratories (Lei et al., 2015; Hidayat, 2015). The battery used was a recycled used laptop battery type 18650, which had 5 battery cells variation (Love et al., 2014).

The research was conducted in several stages: disassembling the casing of the used laptop battery, analyzing the physical feasibility, cleaning the welding point of positive and negative poles of the battery to remove any toxic materials (Fu et al., 2015), measuring the voltage, charging and draining the battery content (Keil & Jossen, 2016), analyzing temperature when power charging from electric outlet to power bank (Waldmann & Wohlfahrt-Mehrens, 2017) "ISSN": "00134686", "abstract": "During charging at low temperatures, metallic Lithium can be deposited on the surface of graphite anodes of Li-ion cells. This Li plating does not only lead to fast capacity fade, it can also impair the safety behavior. The present study observes the effect of rest periods between Li plating and subsequent accelerated rate calorimetry (ARC, installing the battery in integrated instrument tools, analyzing power capacity level indicator lamp (Kornbluth & Erickson, 2012) health, and environmental costs of

kerosene, candles, and other fuel-based lighting are well-documented. As a result of efforts by the World Bank and other organizations, numerous lighting products incorporating solar photovoltaic and light-emitting diodes (LEDs), trying the circuit by adding electric load, analyzing voltage when power charging from power bank to recharged device, analyzing transferred power capacity, and analyzing the time needed to charge device using power bank. The nature of conservation in learning is aimed to accustom students to behave in an environmentally friendly behavior, since the natures of conservation are to care, protect, and repair the environment (Machin, 2013).

Instrument testing was conducted to 6 integrated instrument tools of power bank fitted with recycled used laptop batteries, each consisted of 5 cells of type 18650 battery. The experiment was conducted alternately, in February – March 2017. The data were collected through observation during power bank experiment by project instrument. Instrument data collection was conducted to represent overall integrated instrument tools of power bank. They were then analyzed by descriptive method, both quantitative and qualitative consisting of data reduction and process of determining conclusion.

## RESULTS AND DISCUSSION

The research was conducted through stages as follows: (1) disassembling the casing of the used laptop battery; (2) analyzing the physical feasibility; (3) cleaning the welding point of positive and negative poles of the battery to remove any toxic materials; (4) measuring the voltage; (5) charging and draining the battery content; (6) analyzing temperature when charging power from electric outlet to power bank; (7) installing the battery in integrated instrument tools; (8) analyzing power capacity level indicator lamp; (9) trying the circuit by adding electric load; (10) analyzing voltage when power charged from power bank to recharged device; (11) analyzing transferred power capacity; and (12) analyzing the time needed to charge device using power bank.

The disassembling process of laptop rechargeable battery type 18650 resulted in product as shown in Figure 1. Based on the technical data, type 18650 batteries have some specifications, namely: 18 mm diameter, 65 mm height, 4.2 volt voltage, 2000 mAh power capacity.



**Figure 1.** Type 18650 Batteries Fitted with Recycled Laptop Batteries

There were some physical indicators used to indicate that the batteries still worked normally, namely: 1) not excreting fluids or gases; 2) not having any bulge; and 3) not corroding. The performance of rechargeable batteries is the most important thing in power bank circuit.

The desired power bank module is shown in Figure 2. A power bank module consisted of some components: 1) 5 compartment batteries channel; 2) Micro USB charging socket with specification of  $5V \pm 5\% \approx 1A$ ; 3) electrical outlet-to-power bank charging protection circuit; 4) 4 LED power capacity level indicators; 5) power bank-to-recharged device charging protection unit; 6) female USB port with specification of  $5V \pm 5\% \approx 2,1A$ ; 7) power indicator lamp; 7) on/off switch.



**Figure 2.** Power Bank Module

The power bank casing used in this research is shown in Figure 3. It had some features as follows: 1) It was made of PP Plastic Compound; 2) it had USB and micro USB slots; 3) it enabled the users to change the battery by themselves. The arrangement for batteries is in parallel circuit.



**Figure 3.** Power Bank Casing

The electrical load used to test the produced power bank was a portable LED lamp consuming 1.2 watt on 5 volt voltage, connected through USB port, as shown in Figure 4.

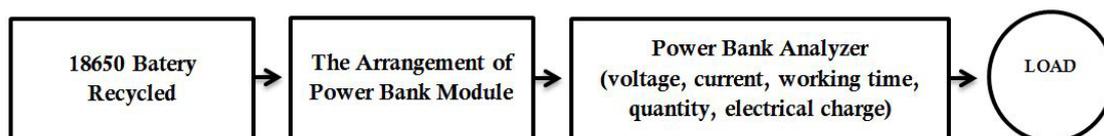


**Figure 4.** 5 volt, 1.2 watt USB Portable LED Lamp

The experiment was conducted by following scheme as shown in Figure 5. First, 5 type 18650 batteries were installed in parallel circuit, and then they were connected to the power bank module. After that, analyzer was installed, and finally, an electrical load of portable LED lamp was connected.

Based on technical data, type 18650 batteries had 4.2 volt output voltage and 2000 mAh power capacity. If 5 parallelly-arranged battery cells were used in an integrated instrument tools, the ideal battery capacity accumulation produced in accordance with technical specification was  $5 \times 2000 \text{ mAh} = 10000 \text{ mAh}$ .

The calculation of power bank capacity according to specifications prescribed was 10000 mAh, meaning that the battery could provide electrical current of 2.1 A for  $10000/2100 = 4.762$  hours, as shown in Figure 6. Based on the energy equation of  $E = P \times t = V \times I \times t$ . It could be calculated that  $5 \text{ volt} \times 2.1 \text{ ampere} \times 4762 \text{ hours} = 50.0 \text{ watt hours}$ . Therefore, the energy storage capacity of power bank tested was 50.0 watt hours.



**Figure 5.** Scheme of Performance Analysis of Power Bank Fitted with Recycled Laptop Batteries

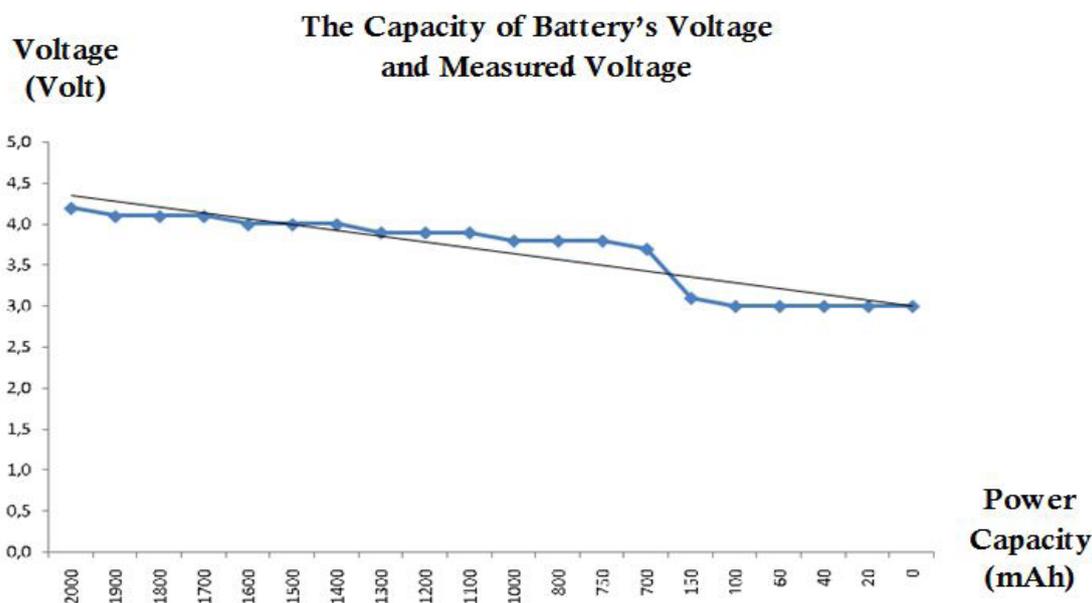


**Figure 6.** Power Bank Battery Analyzer (Voltage, Electrical Current, Working Time, Battery Power Capacity)

Visually, the result of power bank capacity test with electrical load is shown in Figure 7. The power bank capacity was drastically reduced when connected to electrical load, at the time when the voltage reached 3.7 volt. After that, the voltage was stable, at the range of 3.0 volt with

hout experiencing any reduction, even though the load was still connected. However, in this situation, the current rate to the electrical load stopped, in a condition as same as when the switch opens. In a normal battery, the minimal lowest voltage is 3.0 volt. If the battery voltage is under 3 volt, it indicates that the battery may be broken.

From the calculation according to data obtained from measurement, it was found that the electrical current was 0.21 ampere, the voltage was 5.22 volt, and the time estimation was 40.755 hours. Thus, the energy capacity =  $P \times t = V \times I \times t = 5.22 \text{ volt} \times 0.21 \text{ ampere} \times 40.755 \text{ hours} = 44.6756 \text{ watt hours}$ . Based on the calculations, the comparison between the energy capacity based on specification and the energy capacity based on measurement was 89%.



**Figure 7.** Measurement and Analysis of Battery Power Capacity when Connected to Electrical Load

Since the load requirements of power bank in this experiment was a 5 volt LED lamp, then the power bank should convert the battery voltage from 4.2 volt to 5 volt, so that the mAh value of power bank also changed in accordance with the comparison value of battery voltage with output voltage formed. In this case, the constants of multiplying factor to the mAh of power bank appeared which was resulted from calculations of  $4.2 \text{ volt} / 5 \text{ volt} = 0.84$ . It should be noted that each power bank had its certain efficiency level, meaning that not all mAh could be fully stored 100%. It was caused by the material and electronic limit of power bank, which resulted in the loss of charge capacity, or in other words, uns-

tored charge capacity, assuming that the power bank was still capable in storing power, with 90% efficiency level. Based on the data of constants of multiplying factor and efficiency level of power bank, then it can be assumed that a power bank with 10000 mAh specification had the actual mAh value of  $0.84 \times 10000 \times 90\% = 7560 \text{ mAh}$ .

Table 1 shows that the indicator of capacity level of battery based on measurement result indicated the accuracy of LED view. In addition to showing the change in total LED lit, the indicator also marked power charging from electric outlet to power bank and power charging from power bank to recharged device by blinking with the same frequency of blinking in each lamp.

**Table 1.** Indicator of Capacity Level of Power Bank Battery

LED Color	Battery Level (%)	Voltage Range (Volt)	Info
Dull Red	0 - 25	3.00 – 3.59	Low
Bright Red	25 - 50	3.60 – 3.89	Middle
Yellow	50 - 75	3.90 – 4.04	High
Green	75 - 100	4.05 – 4.20	Full

Overall, the performance of each part of power bank was in accordance with the plan. This shows that integrated instrument tools of power bank by using recycled laptop battery product could be used as learning media for project-based physics course. At the time of charging power from electrical outlet to power bank, the battery did not reach 60° C in normal charging time. At the time of charging power from power bank to recharged device, the battery delivered the current steadily. The parallel circuit of 5 type 18650 battery cells with different capacities could have the performance of 89.4% after experiment, compared to technical specification work method.

## CONCLUSION

It was discovered from this research that the performance of power bank using recycled laptop battery which would be used as a project learning media at Vocational High School was 89.4%, compared to the technical specification, based on the data obtained. The integrated instrument tools of power bank using recycled laptop battery is feasible to be used as a learning media for project-based course, especially at Vocational High School with ICT area of expertise. In the future, it is hoped that the development of integrated instrument tools can be directed to using alternative energy resources, such as adding solar panel modules.

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## ENHANCEMENT OF STUDENTS' BIOLOGICAL LITERACY AND CRITICAL THINKING OF BIOLOGY THROUGH SOCIO-BIOLOGICAL CASE-BASED LEARNING

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### ABSTRACT

Biology is a leading science and a foundation in everyday life for all people. Biology student teachers need to be equipped with biological literacy and critical thinking skills in order to teach biology in the future. This research is aimed at determining the effect of socio-biological case-based learning on biological literacy and critical thinking skills of biology student teachers compared with the traditional learning (lecture-based learning). Socio-biological case-based learning is a model of problem-based learning by placing biological cases as a problem to be explained and solved through a series of investigative activities. This research was a quasi-experimental conducted at the Department of Biology, Universitas Negeri Malang. The research samples were the first year students who programmed the General Biology course, consisting of 29 students as a control group and 33 students as experimental group. This research was conducted in September-December 2015. The data of biological literacy and critical thinking were collected from pre-test and post-test. The data were analyzed using ANCOVA test. The research showed that there was a significant difference of biological literacy and critical thinking skills between the students taught by using socio-biological case-based learning and those taught by using lecture-based learning. The research indicated that the socio-biological case-based learning could enhance the biological literacy and critical thinking skills of biology students teachers.

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**Keywords:** biological literacy; critical thinking skills; socio-biological case-based learning

### INTRODUCTION

Students are more motivated to solve authentic problems and show the preference for learning activities through a process of thinking and working, rather than just learning by listening (Lombardi & Oblinger, 2007). Educators also believe that learning by doing is an effective learning process. A challenging, effective, and meaningful instructional approach for students in responding to the problems around them is to

focus on understanding real-world problems and judging solutions (Lombardi & Oblinger, 2007; Bozalek et al., 2013).

Teaching science is to give the experience of discovering science concepts through the scientific process, connecting the science with technological advances and their impact on environment and society (Mansour, 2009) not just about ensuring science education to produce the next generation as an excellent scientist (Nurse, 2016). Currently, science education should prepare generations to become citizens who can apply their science knowledge to respond socioscienti-

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fic issues and participate effectively in democracy (Nurse, 2016). Science education should help people to have adequate knowledge so that they can make informed choices, engage in science development, make decisions on science issues and their impact on technology and society, and enrich the scientific knowledge needed to work in the era of knowledge-based economy (Umoren, 2007; Autieri et al., 2016).

Scientific literacy and critical thinking are the key components of science education which aims at preparing future generations to function as responsible citizens for the advancement of the world affected by science and technology and to understand its impact (Vieira & Tenreiro-Vieira, 2014). In higher education, scientific literacy and critical thinkings are a phrase that has become policy initiatives and educational purposes today (Heinsen, 2016). Scientific literacy and critical thinking trigger the development of knowledge, attitudes/values, thinking ability, and fostering the ability to take responsible action in the context and circumstances by their lives and social environment (Kek & Huijser, 2011).

Scientific literacy is the main goal of science education around the world (DeBoer, 2000). The purpose of scientific literacy education is to build a scientifically literate society, that is, a society that understands science and its relation to social issues. Thus the importance is not only the mastery of the concept of science but rather the ability to think. Scientific literacy involves mastery of thinking and using scientific methods of knowing and addressing social issues (Choi et al., 2011; Archer-Bradshaw, 2014).

Critical thinking is a required skill in the 21<sup>st</sup> century (National Education Association, 2014). Critical thinking is a necessary skill in both social life and the world of work (Lombardi & Oblinger, 2007). Critical thinking is an essential learning outcome for higher education learners (Perry et al., 2014). Critical thinking is a thinking process that involves higher cognitive processes in information processing to produce new thinking (Choy & Cheah, 2009) through questioning, reasoning, making decisions, and problem-solving (Willingham, 2008). Furthermore, it is said that critical thinking is not solving problems using a manner or a way that has been remembered but using new ways. The process of critical thinking to solve problems requires various components of skills, such as analyzing problems, inductive or deductive reasoning, making arguments, judging, evaluating, making decisions, and effective communication (Lai, 2011; Perry et al., 2014; Wagner, 2015).

In line with the growth of biological science, the demands for the ability to master biological literacy increases. Biological literacy is the development of scientific literacy in a biological context. Biological literacy is the ability to use scientific inquiry to understand and recognize biological issues in society and integrate these ideas into decision making and communicate results to others (McBride et al., 2013). In other words, biological literacy focuses on the use of key concepts in biology to make decisions in solving problems through scientific inquiry.

Research showed that many students could not think critically because their teachers could not integrate critical thinking into their instructional practices every day (Choy & Oo, 2012). On our work in August 2015, the biological literacy of the first-year students of undergraduate biology education in State University of Malang with the sample of 67 students, was still relatively low. This is supported by the collected data that only 6 out of 67 students passed the passing grade of 60 scores. The efforts to improve the critical thinking ability and scientific literacy (including biological literacy) are not only for students but also for teachers and student teachers. Therefore it is necessary to incorporate critical thinking skills and scientific literacy into the curriculum, which trains the science teachers to become critical learners and able to manage to teach that to foster critical thinking and scientific literacy. Critical thinking skill builds the foundation of students' thinking so that they are ready to enter the world of professional practice.

Over the years many models of curriculum and the learning process have been researched and developed to improve the quality of science education, in which all of these associated with building scientific literacy (Lederman et al., 2013) and critical thinking (Masigno, 2014). Lederman et al., (2013) proposed a learning process to develop scientific literacy through scientific inquiry procedure.

Biological literacy and critical thinking issues require efforts to overcome it through the application of particular learning models. To promote biological literacy, it is necessary to examine the suitable learning strategies, that is the learning strategy which teaches the students to conduct an investigation on a socio-biological issue (Illingworth et al., 2012). It has been a lot of research that links between problem-based learning and inquiry with scientific literacy and biological literacy and critical thinking. Problem-based learning (PBL) and inquiry is a student-centered method that has been implemented in many courses

around the world for over four decades. Several studies have shown that PBL and inquiry promote critical thinking and lifelong learning (Carrió et al., 2011). PBL was an effective learning strategy to enhance critical thinking (Masigno, 2014). PBL has a positive impact on students' learning and stimulates students to become lifelong learners. PBL is also a learning strategy that must be mastered by the teachers. Teachers who have the mastery of PBL are capable of promoting critical thinking, collaborative learning, and self-regulated learning (Goh, 2014). The implementation of problem-based learning is important in higher education because it is effective to be combined with the work competition of the 21<sup>st</sup> century (Nguyen, 2009). Research by Baharudin & Jamaludin (2014) found that PBL maximally helped improve students' critical thinking skills and cognitive learning outcomes. Ardianto & Rubini (2016) showed that problem-based learning is an instructional strategy that can improve students' scientific literacy. The implementation of the STEM-based virtual lab through inquiry developed a scientific literacy of students (Ismail et al., 2016). Research by Hairida (2016) concludes that inquiry-based learning effective to develop students' critical thinking. The research by Illingworth et al., (2012) revealed that biological literacy of science students was higher if they study of science through socio-scientific issues.

The use of cases as problems to solve by students in teaching has been investigated. Instruction using case studies involves students making analysis, problem-solving, decision making, and justification (Barkley, 2010). The research by Zeidler et al. (2005) showed that the students who used case-based learning achieved a high learning outcome. The lecturer who implemented case-based learning improved students' thinking ability as much as 40% using up to date cases (Hasslöf et al., 2014). Case-based learning improves the content retention and decreases misconception (Rybarczyk et al., 2007).

Application of PBL in biology teaching is better by using contextual biological cases. The socio-biological case-based is a teaching model modified version of a problem-based learning that focuses on using biological cases and issues as problems to solved by students. We use the term model of teaching refers to the explanation Arends (2012). The socio-biological case-based learning is a pedagogical method that uses cases and issues in society related to the concept of biological science as a foundation of inquiry and scientific thinking (Rybarczyk et al., 2007). The socio-biological case-based learning pro-

vides students practice inquiry activities, high-order thinking skills, and collaborative skills in studying biological processes in the relevant real world context. This research aims to examine the effect of socio-biological case-based learning in improving biological literacy and critical thinking skills of biology student teachers compared with lecture-based learning..

## METHODS

This research was conducted on two classes of biology student teachers. The study used a nonequivalent pretest-posttest design (Creswell, 2012). The independent variables were teaching model consisting of socio-biological case-based learning (SocBioCBL) and lecture-based learning (LBL). The dependent variables were students' critical thinking skills and biological literacy. This research was conducted in September-December 2015 in the General Biology course.

This research was conducted at the Biology Education, Universitas Negeri Malang, Indonesia. The total sample of this research was 62 students. Through random sampling, class B with a total of 33 students were selected as SocBioCBL group, and class C with a total of 29 students selected from LBL group. Before the research, both groups were tested for the equality, and the results showed that the learning outcome was equal.

SocBioCBL and LBL Learnings were implemented for 12 weeks at the General Biology course in two different classes. Learning topics in both strategies were similar, namely Basic Concepts of Biology and History of Life, Cell as System and Its Role In the advancement of Biology, Biodiversity, Growth and Development of Plants, Anatomy of Animals and Their Relation with the Physiology Process, Systems In Living organisms, Immunity Systems and Bioprocess, Growth and Development of Animals, Inheritance, Evolution, Ecology, Microbiology and Biotechnology.

SocBioCBL Learning uses the stages of problem-based learning according to Arends (2012) which has been modified, namely orienting the students to socio-biological problems, organizing student to plan problem-solving process, group investigation, developing and presenting artifacts and exhibits, and analyzing and evaluating the problem-solving process.

The research data of biological literacy and critical thinking skills were collected through a pretest and posttest. Biological literacy was measured using biological literacy tests, a multiple-choice test consisting of 20 items. The key indica-

tors of biological literacy were adapted from the scientific literacy indicators referring to Gormally et al. (2012), namely understanding methods of inquiry that lead the discovery of scientific knowledge; and organizing, analyzing, and interpreting the quantitative data and scientific information. Critical thinking skills test referred to the indicators according to Greenstein (2012), namely making a conclusion based on the evidence, formulating assumptions, deducing, interpreting, and evaluating arguments.

Data in this research were pretest and posttest of biological literacy and critical thinking. Covariance analysis (ANCOVA) was used to determine the significant differences in biological literacy and critical thinking between SocBioCBL and LBL.

## RESULTS AND DISCUSSION

### Biological Literacy

The data of biological literacy were collected from pretest and posttest. In the LBL group, the mean pretest score was 38.18 and the mean posttest was 33.29. In the SocBioCBL group, the mean pretest score was 52.12 and the mean posttest score was 69.22 (Table 1). In the calculation of corrected scores, the mean score of LBL becomes 34.35 and SocBioCBL are 68.29.

There was a decrease in the mean score of biological literacy as much as 12.79%, while on the SocBioCBL the mean score of biological literacy increased as much as 32.81%.

**Table 1.** The Mean Corrected of Score Biological Literacy

Model	Pre-test	Post-test	Difference	Corrected mean
Lecture based learning	38.18	33.29	-4.88	34.35
SocBioCBL	52.12	69.22	17.10	68.29

The data of biological literacy were analyzed using ANCOVA to know the difference of biological literacy between the students taught by using SocBioCBL and those taught by using LBL. The Summary of ANCOVA of biological literacy analysis is presented in Table 2. The results of ANCOVA show that there was a difference in the biological literacy between the students taught by using SocBioCBL teaching model and those taught by using LBL (Table 2). Based on this analysis showed that biological literacy of the students taught by using SocBioCBL teaching model was significantly higher than that of the students taught by using lecture based learning.

**Table 2.** The Summary of ANCOVA of Biological Literacy Data

Source	Type III Sum of Squares	Df	Mean Square	F	Significance
Corrected Model	20090.990(a)	2	10045.495	115.806	0.000
Intercept	7569.573	1	7569.573	87.263	0.000
Literacy	166.420	1	166.420	1.919	0.171
Model	13007.059	1	13007.059	149.948	0.000 <sup>*)</sup>
Error	5117.893	59	86.744		
Total	195550.820	62			
Corrected Total	25208.884	61			

<sup>\*)</sup> Significance at  $p \leq 0.05$

SocBioCBL improves students' biological literacy because students recognize biological problems and issues, find information that explains the problem, propose a hypothesis in solving problems, investigate, and solve problems arising from this problem. Students analyze the clarity of the problem by referring to valid biological information. Problem-solving starts from the question formulation. Questions identified in problem-solving according to students' way of thinking, so this question helps students solve science problems in everyday life. The example

is in the case of biological use of alcohol in beverages. Students assess whether alcohol gives warmth to the body. Students analyze whether the information is correct by using data from investigation and reference. After finding the best solution for the problem and issue, the students presented information that alcohol does not give warmth to the human body. Students taught with SocBioCBL can assess the validity of issues based on correct scientific arguments. Using the correct argument is one of the most important indicators of literacy as a basis for scientific thinking.

### Critical Thinking Skills

The corrected mean of the critical thinking skills of the students taught by using lecture-based learning was 51.12 and the corrected mean of the critical thinking skills of the students taught by using SocBioCBL was higher, which was 73.32 (Table 3). The students implementing SocBioCBL and lecture-based learning increased by 74.03% and 62.88%, respectively. The data of students' critical thinking skills on the pretest and posttest were analyzed using ANCOVA. The re-

sults showed that the *p*-value of the teaching model was 0.008 (Table 4).

It means that there was a difference in the critical thinking skills of the students taught by using SocBioCBL and those taught by using lecture-based learning. The data reveal that the critical thinking skill in SocBioCBL is higher than CBL. The data showed that SocBioCBL improves critical thinking skill of students than lecture-based learning.

**Table 3.** The Mean Corrected of Score Critical Thinking Skills

Model	Pre-test	Post-test	Difference	Corrected Mean
Lecture based learning	28,96	47,17	18,21	51,12
SocBioCBL	49,87	86,79	36,92	73,32

\*) Significance at  $p \leq 0.05$

The challenge of teaching and learning process in higher education to preparing biology teacher is to equip them with global life skills such as scientific literacy (including biological literacy) and critical thinking skills (Dani, 2009). Teachers should teach critical thinking skills to the students because critical thinking skill is used in everyday life (Sendag & Odabasi, 2009). According to Paul

& Elder (2007), critical thinking encouraged students to select cases and solve them using various ways.

Biological literacy and critical thinking can be developed using the appropriate learning strategies or learning model. This study provides experimental evidence that socio-biological case-based learning fosters biological literacy and critical thinking skill.

**Table 4.** The Summary of ANCOVA on The Data of Critical Thinking Skills

Source	Type III Sum of Squares	df	Mean Square	F	Significance
Corrected Model	2156.237(a)	2	1078.118	15.964	0.000
Intercept	11831.243	1	11831.243	175.188	0.000
XC.Thinking	729.116	1	729.116	10.796	0.002
MODEL	34.458	1	34.458	0.510	0.008*)
Error	3984.537	59	67.535		
Total	330146.000	62			
Corrected Total	6140.774	61			

The teaching strategy that develops the ability of students to read critically, to write ideas, and to discuss ideas (DeBoer, 2000) is used to increase scientific literacy. Socio-biological case-based learning is the development of problem-based learning, by presenting the biological problems that are happening today in our daily lives. Problem-based learning is a student-centered learning model that uses problems as a foundation for learning to solve problems through a series of scientific process skills and scientific thinking skills. Students who learn through problem solving have good knowledge because problem solving fosters critical thinking and critical thinking triggers the development of knowledge (Kek & Huijser, 2011).

The results of the data analysis showed that SocBioCBL improved students' critical thinking skills and biological literacy. Research conducted by Cahyarini et al. (2016) showed that the instructional model of socioscientific issues can improve critical thinking on acid-base. The improvement of students' critical thinking and biological literacy is because SocBioCBL learning model familiarized the students to analyze cases and to process information that was considered correct, effective and productive. Barret (2005) reveals that students taught using case analysis will explain the facts of the case and determine the solution of the problem so that his/her critical thinking skills develop.

Developing someone's scientific literacy can be done by identifying questions, connecting background knowledge and new knowledge, explaining the phenomena that occur in accordance with science, illustrating the fact between science and related issues (Bybee et al., 2009). On SocBioCBL learning model, the students were taught using cases which were presented in questions. After that, the students searched for the best solution to the cases. Teaching science to students should balance the teaching of theories and field practices which involve the identification of facts, explanation, and investigation.

The challenge in solving learning problems through cases depends on the ability of teachers to select and expose biological based cases or issues in the community. Cases are descriptions of a story which is rich of problems, knowledge, and skills that are used to encourage students to think, so that it can help student think to solve the problems (Lee & Jieun, 2009). According to Delisle (1997), the formulation of problems must be adapted to the students' skills. Thus, the success of SocBioCBL depends on the problem selection by the teacher. Teachers can formulate problems by developing an interesting form of questions for the students.

Socio-biological case-based learning provides benefits to the achievement of learning outcomes, which is to link the mastery of biological concepts and their relationship to the social context (Allchin, 2013). Using real-world problems in teaching will lead to the discovery of biological science concepts and encourage students to view biology not only as a collection of concepts but provide experience of making biological connections with other disciplines including sociocultural issues (Kloser, 2012). In socio-biological case-based learning, lecturers act as facilitators to monitor the increase of students' thinking skills (Wee, 2004). The facilitator encourages the students to think creatively and critically in finding the best solution to the problems, ranging from less structured to complex problems (Hmelo-Silver, 2004).

## CONCLUSION

This study provides experimental evidence that socio-biological case-based learning enhances biological literacy of biology students as well as a critical thinking skill. The evidence presented in this study offers additional support for the use of socio-biological case-based learning

as a curricular vehicle for student learning about biological literacy and critical thinking skill. The faculty members are advised to use this teaching model in conducting teaching biology. The challenge in implementing this teaching model is the instructors' creativity in identifying socio-biological cases that require solutions faced by society and students in everyday life. Faculty member should understand that problem solving requires the instructor to function as a facilitator to help students can actively think, judging, and making a decision to response the biological issues.

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## DEVELOPING LEARNING MEDIA USING ONLINE PREZI INTO MATERIALS ABOUT OPTICAL EQUIPMENTS

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### ABSTRACT

The instructional media used at schools are not maximized. Therefore, researchers developed an internet-based instructional media using Prezi online software. The objectives of this study are: (1) to describe the instructional medium validity using Prezi; (2) to describe the practicality of Prezi medium as an evaluation from students' questionnaire responses; and (3) to describe the effectiveness of Prezi medium seen from students' learning outcomes. This media development refers to the KEMP model development. The instruments used were in the form of media validation sheet, student questionnaire responses, and achievement test. The results showed that: (1) the validity of the medium category is very valid; (2) the practicality of the medium is on the very practical category; (3) the effectiveness of the medium is on the effective category. It is concluded that the Online Prezi instructional medium which was developed is eligible for use in learning.

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**Keywords:** prezi online; media development; optical equipment

### INTRODUCTION

Teachers are obliged to plan good quality learning, as well as assess and evaluate learning outcomes in carrying out the tasks of professionalism. In addition, teachers also have a duty to improve and develop the academic qualifications and competence on an ongoing basis in accordance with the development of technology and art. Teachers should be able to keep abreast of technology to improve learning outcomes. One of them is developing the media with the latest current technology.

Instructional media can be used as an alternative source of learning in the learning process (Alimah, 2012). Well-designed instructional media will greatly help students digest and comprehend the subject matter (Muhson, 2010). Interesting learning media are also able to stimulate

students' attention to the material presented by teachers so that the material is more easily understood by Students (Utari et al., 2014). The use of multimedia in the learning process will help students in the learning process because the teaching materials become visible (Ramansyah, 2014).

The use of media for learning in schools, such as computers, projectors, and internet networks, is still not optimal. This can make students feel bored and uninterested in learning; as a result, students learning outcomes would be below the minimum criteria of mastery.

The physics learning in the school-based curriculum is expected to include better interaction and communication between teacher and students so that the learning objectives can be achieved well. Effective and efficient physics learning process can be realized well if teachers use appropriate instructional media so that students' learning outcomes can be optimum (Melida et al., 2014).

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One of the alternatives of the media that can be used is internet-based instructional media using Prezi online software. Prezi is internet-based software which is used as a media presentation as well as a tool to deliver ideas on a virtual canvas (Rodhi & Wasis, 2014). Prezi offers several new techniques in the presentation, which make the presentation more interactive and detailed (Good & Bederson, 2002). Prezi's excellence is its Zooming User Interface (ZUI), that is the ability to zoom in and zoom out the presentation slides (Brock & Brodahl, 2013).

Prezi is an effective instructional tool to improve students' learning process (Conboy et al., 2012). Prezi is a more effective instructional medium for gaining knowledge compared to the traditional media (Chou et al., 2015). Prezi is a transformative tool that builds students' ability to present information through logical, visual, and spatial relationships (Manning et al., 2011). Prezi medium usage makes it easier for students to understand information, and to insert a variety of pictures, photographs and videos to support the ease of preparing the presentation slides (Utari et al., 2014). This is because the Prezi medium is equipped with multimedia integration, therefore, the medium can combine photos, videos, images, and animations (Sari, 2014).

The use of Prezi media can be said to be effective as a medium of physics learning (Utari et al., 2014). The instructional medium application using Prezi software can increase students' learning interest (Suharjanto, 2014). In addition, Prezi presentation medium also positively influences students' learning outcomes (Mardiansyah et al., 2017) and can enhance students' critical thinking skills (Aotar et al., 2017). The previous study by Fitri (2016) stated that the application of learning through the Prezi medium can improve students' learning mastery. The instructional media can hopefully provide maximum results in the learning process (Taufiq et al., 2014).

Based on this research background and the development of an instructional medium using Prezi Online software, this research was conducted with the aim of producing an instructional medium using Prezi online software on optical devices topic which is feasibly used in the study based on validity, practicality, and effectiveness.

## METHODS

This is a Research and Development. This study developed Internet-based instructional medium using Prezi Online software on optical

devices topic. The employed model development was by Kemp. Kemp's model emphasizes interdependence in every stage of the process, it also emphasizes on evaluation and it involves many factors in the educational field, such as resources, facilities, and time (Ibrahim, 2015).

The subjects of the try out were the students of Class X-1 SMA Negeri 8 Banjarmasin academic year 2015/2016, there are 29 students involved. Research data were collected through observation, distribution of questionnaires, as well as a written test. The validity was measured through the media validation sheet, then using the passing grade ( $X$ ) which was the average score of the assessment results of academic and practitioners validators, and adapted to the media aspect of the assessment criteria that have been developed in Table 1.

**Table 1.** Criteria for Validating the Instructional Media

Interval	Category
$X \geq 3.25$	Very valid
$2.5 < X \leq 3.25$	Medium validity
$1.75 < X \leq 2.5$	Low validity
$X \leq 1.75$	Invalid

(Sudijono, 2009)

The practicality of the developed media was measured using students' questionnaire responses using the criteria in Table 2.

**Table 2.** Instructional Media Practicality Criteria

Interval	Category
$X \geq 3.25$	Very valid
$2.5 < X \leq 3.25$	Medium validity
$1.75 < X \leq 2.5$	Validity is low
$X \leq 1.75$	Invalid

The media effectiveness was measured using achievement test and analyzed using a normalized gain (N-gain). The media effectiveness criteria are seen in Table 3.

**Table 3.** Criteria of The Instructional Media Effectiveness

Value	Criteria
$\langle g \rangle \geq 0.7$	High
$0.7 > \langle g \rangle \geq 0.3$	Medium
$\langle g \rangle < 0.3$	Low

(Hake, 1998)

## RESULTS AND DISCUSSION

The medium was tested, students' questionnaire responses, and achievement test were validated by two validators. Table 4 shows the

results of media validation. After the validation was carried out, the try out was done in the class X-1 SMA N 8 Banjarmasin which consisted of 29 students. The data obtained were from the media practicality of the students' questionnaire responses and effectiveness of media of the learning outcome test.

**Table 4.** Media Validation Results

Aspects of Assessment	Average	Category
Presentation variation	2.75	Good
Enforceability	3.17	Good
Completeness of the media	3.00	Good
Media design	3.75	Very Good
Thorough look	3.00	Good
Validity	3.13	Valid
Reliability	0.70	High

Table 5 shows the results of students' questionnaire responses. The physics learning media validation consists of five aspects, such as, variations in the presentation, enforceability, media completeness, good category of overall display and good category of media design.

**Table 5.** Results of The Analysis of Students' Questionnaire Responses

Indicator	Average	Category
Ease of use	3.54	Very Practical
Benefits	3.48	Very Practical
Time efficiency	3.49	Very Practical
Average	3.50	Very Practical

Table 6 shows the learning outcome test. The validation result of the instructional media by academics and practitioners earned an average score of 3.13 with a valid category for the validity and gained 0.70 by the category of high reliability.

**Table 6.** Results of The Students' Learning Outcomes on The Pretest and Posttest

On average pretest	On average posttest	N-gain	Category
25.36	77.90	0.70	Effective

The media practicality was acquired from students' questionnaire responses. According to Nieveen (Hobri, 2010) "the practicality aspects are associated with the experts and practitioners who state that the media developed can be applied, and that the application in the field is seen from students' response questionnaire". Practicality aspect is measured by the aspects of ease of use, benefits, and efficiency of learning time. The results of the analysis of the practicality obtained an average score of 3.50 with a very practical category. Prezi is easy to use, and it attracts students to learn (Mustafa et al., 2013). Students can use Prezi to work more easily together in projects (Strasser, 2010). Prezi medium has many advantages (Perron & Stearns, 2011), including (1) the ability to integrate text, images, animation, audio, and video into a single presentation; (2) having almost the same concept as mind mapping so that users can see all the elements of overall presentation; (3) can be used as a tool to create dynamic and informative presentation, because there are many templates; (4) is accessible online and offline; and (5) provides zooming out and zooming in that makes it easier for users to use, and the content can be delivered well (Brock & Brodahl, 2013).

The use of media makes the role of teacher only as an intermediary in the learning process, but it can make students motivated so that students become more active in learning (Mahbub et al., 2016). The developed instructional media effectiveness was obtained through achievement test and analyzed through the achievement test. According to Hobri (2010), "aspects of the media effectiveness can be seen from the mastery of students' cognitive learning outcomes". Based on the calculation, the result of the  $\langle g \rangle$  was 0.70; , thus, it is categorized in the effective category. Prezi instructional medium influences the learning outcomes as it can improve students' learning outcomes (Brock & Brodahl, 2013; Virtanen et al., 2013; Wirawan, 2015). Therefore, Prezi is an effective instructional media to acquire some knowledge, and it can improve students' conceptual understanding (Akgun et al., 2016; Chou et al., 2015).

Prezi medium use in learning motivates students to be active and creative, improves students' imagination, clarifies complex events, and reveals the material or object that cannot be directly displayed so that learning becomes innovative and fun. The application of Prezi zooming presentation medium on physics learning gave a significant impact on improving students' learning outcomes in the cognitive, affective, and psychomotor components characterized by improvement of students' learning outcomes (Melida et al., 2014).

## CONCLUSION

Based on the results of development and try-out, it can be concluded that the Internet-based instructional media using Prezi online software on optical equipment topic is feasible to use. This is supported by: the validity of this developed medium based on the validation results, is categorized as very valid, with an average score of 3.25; the practicality of the developed media, measured by students' questionnaire responses, is categorized as very practical, with an average score of 3.50; and the media effectiveness is in the category of effective, with a score of 0.70.

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## HABITUATION MODEL OF IMPLEMENTING ENVIRONMENTAL EDUCATION IN ELEMENTARY SCHOOL

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### ABSTRACT

The purpose of this study is to analyze the implementation of environmental education in Elementary School. The study was conducted at SDN 1 Kota Banda Aceh. The research subjects are school residents (students, teachers, education personnel, principals, and school committees). This research is designed using a qualitative approach. This study is focused on the implementation of environmental education in primary schools. Data collection uses observation sheet instrument (observation), focused interview, and Focus Group Discussion (FGD). The research data were analyzed descriptively. The results show that the implementation of environmental education can be realized in habituation to maintain personal hygiene, class cleanliness, and worship together according to his beliefs and sports.

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**Keywords:** environmental education; habituation; personal hygiene; class cleanliness; worship together

### INTRODUCTION

Environmental damage is unlikely to be prevented or avoided, but it can be systematically controlled by implementing sustainable development, supported by Education for Sustainable Development (ESD). ESD can be introduced in various levels of education, either through intra or extra curricular activities. One solution to instill character and sensitivity on the socio-cultural, environmental, and economic aspects in order to guide students in the right environment is the Education for Sustainable Development approach abbreviated as ESD (Rohmah, 2014). ESD is developed in several countries that have local problems which bring impact globally (Segara, 2015). ESD is equivalent to environmental education (Nomura, 2009). According to Suduc, et al., 2014, ESD is an appropriate educational program to educate people early to

reduce human dependence on the natural and social environment.

Afandi (2013) stated that environmental education by utilizing the school environment as a learning resource would create a green school. According to Ozden (2008), many people believe that environmental education is the most important factor to prevent environmental problems. Research by Prabawani et al. (2017); Bahri, (2016) showed that by applying ESD, elementary school students in Semarang City have a better understanding in the pillars of learning nature, social, and ego sustainable development. Students who are active in the school must also get an education about the character of environmental care in order to play an active role as their parents (Prasetiyo & Suyanto, 2013).

Various parties (government, companies, and NGOs) have launched ESD programs. Listiawati (2013) pointed out that WWF instills love for the natural environment and biodiversity, trains teachers to incorporate these values into

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the curriculum, as well as school governance, called the love triangle (love to God, to fellow man, and to nature). The proclaimed program is related to three perspectives in life namely social, environmental, and economic aspects. The details are presented in Table 1.

**Table 1.** Program Institutions and Implementation in School

Board of Trustees	Program	Implementation in School
KLH	Adiwiyata	1. Social: health 2. Environment: planting tree, 3. Economy: Sorting and utilizing garbage
Secretary of Directorate General of Elementary Education	Education for Development, Development and/or Sustainable Development (PuP3B)	1. Environment: planting, cleanliness (toilets) 2. Socio-Culture: working together in the inner and outer environments of schools, libraries, School Health Efforts 3. Economics: compost processing, honesty canteen 4. Socialization for provincial and district/ municipal stakeholders. 5. Creating 33 model schools (SD and SMP) from 31 provinces.
Directorate of Elementary Education Development, Ministry of Education and Culture	SDBS (Clean and Healthy Elementary School)	1. Working policies and programs Facilities and infrastructure Instilling clean and hygienic behavior Bolck grand 3 SD in each district/city throughout Indonesia
Center for Policy Research, Department of Research and Development, Ministry of Education and Culture	Integrating ESD values into learning process	Socio-Culture Human rights (right to self-development), security, health, development of character Environment Reboisatation Economics: entrepreneurship
WWF	ESD Program in School	Training and workshop: ESD, entrepreneurship, Writing skills  Help schools become ESD dream schools: school management, curriculum, school participation in communities and communities in schools, Infrastructure, school planning and planning, school self-evaluation, and school planning activities for six months or 1 year  Coordinator of ESD implementation in schools. Create a mulch module on environmental maintenance and disaster mitigation.
Sekolah Sobat Bumi (Pertamina Foundation)	Program management and utilization of SDA	Biogas: utilization of livestock waste and industrial waste into gas (biogas and bioethanol) for cooking. Source: Listiawati (2013), edited

Environmental education in Elementary School is an integral part of ESD. The "output" of sustainable development agents can be optimally generated by reforming the grading of cognitive, affective, and psychomotor aspects. Knowledge and understanding of the concept of sustainable development are important, but planting attitudes toward the meaning of sustainable development (right and whole) is no less important.

Attitude is a reaction or special response to a stimulus that comes from a person's perception of his environment. Theoretically, perception is divided into two types, namely personal perception and social perception. Personal perception is a process of impression based on observation or reasoning on a matter that influences on physical and psychological. Social perception is a process of impression formation, opinion or feeling to something that involves the use of directed information.

The intention is formed as an interaction of attitudes toward objects to behave and subjective norms about behavior. This is in line with the Medan Theory developed by Lewin (Helmi, 1999). According to Lewin, behavior is a function of the environment (E) and organism (O). Mathematically formulated as:

$$B = f(E, O)$$

Lewin's theory accommodates two opposing views, namely human assessment from internal state and social construction or social engineering. Data collection uses observation sheet instrument (observation), focused interview, and focus group discussion (FGD). Research data were analyzed descriptively.

## RESULTS AND DISCUSSION

Habituation of healthy living begins with the activity of reformulating the vision and mission of the school, which involves all citizens of the school, openly and democratically. The vision of SDN 1 Kota Banda Aceh is "The realization of graduates who have a noble character, discipline, excellence in academic and non-academic achievement, intelligent and responsible and environmentally oriented toward Green School." SDN 1 Kota Banda Aceh Mission is as follows.

- a. Create a learning environment based on noble values.
- b. Develop the potential of students' intelligence through active, creative, effective and fun learning.

- c. Help students to know their potential optimally.
- d. Foster the spirit and soul of discipline and a sense of responsibility towards the task and obligations.

- e. Realize environmentally- friendly schools towards Green School. All the citizens of the school voluntarily and openly bind themselves in a declaration to carry out character education. One character developed is Environmental Care, as Figure 1.

Habituation to maintain personal hygiene (hair, mouth, and teeth, nails, ears, body and clothing), included washing hands before and after meals, becoming good example in a clean and healthy life behavior performed routinely in various forms of School Health Efforts, especially small doctors, as Figure 2.

Habituation keeps the class clean (there are a picket officer and active duty) and the environment, including throwing garbage in its place (organic/non-organic waste), involved in waste management (reduce, reuse, recycle), actively participate in environmental education in school activities (consecrated work, health day, environmental day, etc.), and are involved in the planting and cultivation of crops in schools as shown in Figure 3 and 4.

Habituation of worship together by his beliefs and sports involving all the citizens of the school and other school cultures is presented in Figure 5.

Successful habituation of healthy living as an implementation of environmental education requires careful planning by including financing and involving schoolchildren. It is formulated in vision, mission, and commitment (Figure 1) and other stakeholders such as various government and private agencies. Socialization of the program is a very important stage of habituation. This is in line with Landriany's (2014) study which demonstrates that the vision and mission towards environmental care will create responsible schoolchildren in the effort to protect and manage the environment through good school management to support sustainable development.

SDN 1 Banda Aceh completes various facilities for optimizing healthy living habituation. To achieve habituation to maintain personal hygiene (Figure 2), the school cooperates with Puskesmas and Department of Health which performs routine checks and coaching. Little doctors have sufficient training, so they have the ability to provide first aid before being referred to a Puskesmas. The little doctors are also in charge of checking whether or not there are mosquito larvae in the school bathroom, water basin and the

community around the school. School facilities to support healthy habituation are as follows: (a) Provision of teachers' books on health education; (b) Provision of School Health Efforts space; (c) Provision of minimal School Health Efforts equipment includes: (1) sleeping bed; (2) weight scales, height measuring instruments, Snellen charts, and thermometers; (3) medicine cabinets, first aid kit and simple medicines (wound medicines, oralites, paracetamol, etc.)

The optimization of habituation to maintain the cleanliness of the class is done by forming a picket officer in each class who is in charge of maintaining the cleanliness of the class, doing the work of devotion, engaging in the planting and maintenance of the plants in the surrounding environment. In each classroom, there is a closed, organic and inorganic trash can, and there is a hand-wash place with clean running water equipped with soap and a clean cloth.

SDN 1 Banda Aceh formed an Environmental Police consisting of 5th and 6th graders. Environmental Policemen toured the school du-

ring break times. They are in charge of monitoring and reminding the younger siblings who throw garbage recklessly, picking it up and throwing it in the available bins (Figure 4). In open spaces, a dumpster is provided, covered and given a description (organic/inorganic, wet/dry, and pictorial). Collected plastic bottles are handed over to third parties for recycling (reduce, reuse, recycle). They have the slogan "LISA", "Lihat Sampah Ambil".

The interaction of police environment with students runs very effectively, affecting their interest in behaving environmentally, in harmony with the research results of Cheng and Monroe (2010). Amini's research (2015) shows that learning outside the classroom-based environmental education is effective for improving student learning outcomes and attitudes towards environmental care. Habituation to maintain cleanliness is also applied in the school cafeteria. SDN 1 Banda Aceh provides facilities and infrastructure of school canteens that meet the following health requirements.



Figure 1. Declaration of Character Education Implementation



Figure 2. Habituation of Self-Cleanliness

1. The location of the cafeteria/school stalls is at least 20 m away with TPS (temporary garbage collection).
2. The ceiling looks clean, no dust, no cobwebs, no leaking marks, not broken, not peeling, and easy to clean.
3. Wall looks clean, no dust, no cobwebs, no cracks, and easy to clean.
4. The floor looks clean, not slippery, no garbage strewn, not cracked, and easy to clean.
5. Mebeulair in the form of dining tables and chairs look clean, no dust, and in good condition.
6. School cafeteria equipment looks clean, no dust, not damaged, not easily rusty.
7. There are organic, inorganic, and waste-covered organic trash cans
8. There is a hand wash site with clean running water equipped with soap and a clean clot
9. There is adequate ventilation.
10. Cafeteria looks bright, clean, and neat.
11. Food is stored in a closed place and separate from the finished food.
12. Storage of foodstuff and food according to the recommended storage temperature.
13. Simple food processing (heating, steaming and baking) looks clean, tidy, closed. There are sufficient lighting lights and away from the bathroom/WC.
14. Place of food presentation always closed, clean, and not rusty.
15. Food serving time not more than 4 hours, especially high protein and food with coconut milk is no more than 2 hours.
16. Cooking and cutlery processing equipment is stored in a clean and closed storage area.
17. Washing and cooking utensils look clean with available running water and soap.
18. Around the washing place, there is no stagnant water.
19. The canteen waste disposal channel is made of waterproof and closed material.
20. Hygiene kits (broom, mop, bucket, soap, etc.) are available in the cafeteria
21. Food and beverage packaging sold is undamaged, not expired, contains no hazardous chemicals that are prohibited, and does not use food additives exceeding the maximum limit (including salt, sugar, and fat), and hazardous materials.
22. Clothes keepers clean, tidy, and use brightly colored apron using headgear, clamps, gloves, and masks (if needed) and not talking-sneezing/coughing at the touch of food.



Figure 3. School Picket



Figure 4. School Trash Bank



Figure 5. Habituation of School Culture  
SD Negeri 1 Banda Aceh, Aceh Province

SDN 1 Banda Aceh has a bathroom/WC and a separate urinal and equipment between the male/female students as required and bathroom/WC for teachers and employees. Water does not stagnate in the school environment due to the presence of sewerage channels that meet health requirements such as watertight, covered, and the water can flow smoothly. School also builds bio pores in several locations.

Habituation of worship together according to his belief embodied in praying dhuhur congregation and pray dhuha periodically. SDN 1 Banda Aceh establishes Saturday as the day of creativity. On Saturday there is no lesson, but it is filled with various sports and art activities, involving all the citizens of the school. All parents are invited to do a healthy walk together, then witness the children's art and cultural attractions. Implementation of activities is managed by parents. The committee opened the donor wallet voluntarily. The donation results are publicly announced, posted on the school's information boards. The collected funds are used to help disadvantaged students and support various school activities.

## CONCLUSION

Based on the results and discussion, it can be concluded that the implementation of environmental education can be realized in 3 (three) habituation, namely (1) maintaining personal hygiene, (2) class cleanliness, and (3) worship together according to his beliefs and sports. These three types of habituation will work optimally with the strong support and commitment of all school members: teachers, education personnel, principals, and school committees.

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## CONCEPT ATTAINMENT WORKSHEET TO ENHANCE CONCEPT KNOWLEDGE AND SCIENCE PROCESS SKILLS IN PHYSICS INSTRUCTION

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### ABSTRACT

This research aims to: (1) produce conceptual attainment worksheet; (2) know concept understanding improvement; and (3) know science process skills improvement. This was a development research by using 4-D models (define, design, develop, and disseminate). The development product was tested in grade XI of SMA Negeri 1 Magelang with 20 students for limited test and 33 students for field test. The research produced worksheet based on validator's score from language structure and design PA 96.97%, appropriate learning with conceptual attainment method PA 95.24%, and learning to improve science process skills PA 95%, in which all aspects got the best category. Almost students agreed to the worksheet with presentation 78% for limited test and 89% for field test. Conceptual understanding improvement based on normalized gain was 0.56 for limited test and 0.50 for field test. The improvement of science process skills wasn't significant for all the test with range 0.1-0.3.

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**Keywords:** student worksheet; conceptual attainment; science process skills

### INTRODUCTION

Science included physics is a study to understand about nature. There are four dimensions of science, as a way of thinking, a way of investigating, body of knowledge, and interaction with technology and society (Chiappetta & Koballa, 2010). One of the challenges of 21<sup>st</sup> century is competition between countries, especially in technology. Therefore, Indonesia needs to prepare human resources who capable in mastering not only the technology which needed but also all the 21<sup>st</sup> century skills to ensure the competitive in globalization era, such as skills for life and career, learning and innovation skills, and for sure information, media, and technology skills (Trilling & Fadel, 2009).

Good quality education mainly in science including Physics is expected to solve the 21<sup>st</sup> century challenges. However, based on PISA (Program for International Student Assessment), science literacy result of Indonesian students in 2012 got rank of 64 from 65 countries, it was one level above Peru (Oktarisa, 2016). The result proved that science literacy of Indonesian students are still weak. So it should be increase by how the Physics exactly should be learned.

Learning of science in 21<sup>st</sup> century is focused on investigation method through inquiry process. A learning strategy that using structure of inquiry process is conceptual attainment (Jones & Hilaire, 2014). conceptual attainment is a learning model to help student easily understand about concept. This model applicable from pre-kindergarten to higher education because included of critical inquiry, reasoning skills, and inductive thinking process (Wenno et al., 2016;

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McDonald, 2015). Conceptual attainment is designed to classify objects or events as same as the scientific procedures (Mohan, 2007). Through conceptual attainment model, students compare and contrast examples that contain concept attributes with examples that do not contain. By observing, students discuss and identify the attributes until they develop a concept definition.

Conceptual attainment teaching plan consist of identifying topic, deciding learning aims, choosing examples and non-examples, arranging examples and non-examples (Eggen, 2012). Based on (Kaur, 2014; Kumar & Mathur, 2013; Anjum, 2014), conceptual attainment was better and more effective method in understanding physics concept compared with conventional or traditional method. Therefore, one of idea to learn physics more effectively is by implementing that conceptual attainment model to make a learning-media, such as worksheet which expected to increase not only physics concept understanding but also science process skills. The common difficulty of learning physics (Hung & Jonassen, 2006) is the lack of concept understanding. Kurniawan (2013) stated that to get concept understanding, students required to learn more active. Active and directly learning activity, students would get the concept in long term memory that very helpful for them.

Process skills also needed to get the learning comprehension, which means the whole of concept understanding. Science process skills is main purpose of science concept. This skills include to the scientific inquiry which also support the 21<sup>st</sup> century learning of science (Chiappetta & Koballa, 2010). Concept understanding and psychomotor skills were related each other. Real activity was important in creating the link of life, enabling students to more understand the lesson, getting knowledge, and developing psychomotor skills that included of observation, measurement, classification, data recording, creating hypotheses, using data and gaining the creating

ability, changing and controlling variables, and conducting scientific experiments (Sumarni, et al., 2016). Then, science process skills consist of basic and integrated skills. Basic science process skills consist of observing, classifying, communicating, using time and space relation, measuring and using number, predicting, and inferring. Integrated science process skills consist of defining operationally, controlling variables, interpreting data, hypothesizing, and experimenting (Turiman et al., 2012; Karamustafaoglu, 2011).

Learning material in this study was Equilibrium and Rotational Dynamics. This material was chosen because it contained of classical mechanics basic concepts which applied a lot in daily life. At schools, this material was rarely presented in experimental activities. The learning usually given by mathematical equation so students just memorized the formulas and applied to solve exercise problems. Therefore, this study will develop conceptual attainment worksheet for XI class in materials of 'Equilibrium and Rotational Dynamics' to improve physics concept understanding and science process skills.

## METHODS

This was a development research using design of 4-D Models which developed by Thiagarajan and Semmel (Trianto, 2009). The research steps included: (1) define; (2) design; (3) develop; and (4) disseminate. Developed product in this research was conceptual attainment worksheet to improve concept understanding and science process skills in Equilibrium and Rotational Dynamics.

This research had been done on January 2016. Limited test was done in XI MIA 6 and field test in XI MIA 1, SMA Negeri 1 Magelang. The subjects for limited test were 20 students of XI MIA 6 and for field test were 33 students of XI MIA 1. The procedure of conducting this research can be seen on Table 1.

**Table 1.** Procedure of Conducting The Research

Procedure	Steps
<p><b>1. Define</b> This step aim was to decide and define what be needed in learning.</p>	<p><b>a. First Analysis</b> The aim was to find basic problem of physics learning process which needed a new innovative learning or solution.</p> <p><b>b. Students Analysis</b> This was analysis about student characteristics which concluded thinking skills level, activation in classroom and response to learning that given by teacher.</p> <p><b>c. Assignment Analysis</b> This was procedure to decide contents in learning by detailing the outline of teaching material assignment from Core Competences, Basic Competences, and Indicators.</p>

Procedure	Steps
	<p><b>d. Concept Analysis</b> This analysis was to identify main concepts which be taught and arrange systematically some relevant concepts so it could form a mind mapping.</p> <p><b>e. Learning Aims Specification</b> This step was to formulate learning aims based on Core Competences, Basic Competences, and Indicators which listed in the syllabus.</p>
<p><b>2. Design</b> The aim was to prepare learning media.</p>	<p><b>a. Arranging the Research Instrument</b> This step started by preparing validation sheets for lecturer and teacher, student questionnaires, observation sheets of Conceptual Attainment learning, and observation sheets of science process skills. Then also arranged the data collecting instrument such as worksheet, lesson plan, pretest and posttest.</p> <p><b>b. Choosing Media</b> Media in this developing research was Conceptual Attainment worksheet to improve concept understanding and science process skills.</p> <p><b>c. Choosing Format</b> The format was appropriate with Conceptual Attainment worksheet format to improve student concept understanding and science process skills.</p> <p><b>d. Worksheet First Design</b> It would produce worksheet draft which consisted of cover, preface, content list, mind mapping, Core Competences, Basic Competences, some experiments, and exercise problems.</p>
<p><b>3. Develop</b> This aim was to produce revision worksheet based on comments, suggestions, and scoring from lecturer, teacher, limited test, and field test.</p>	<p><b>a. Lecturer and Teacher Validation</b> Conceptual attainment worksheet had to be validated by lecturer and teacher before using. Revision based on lecturer validation result would produce draft II. Validation consisted of worksheet scoring in language structure and design, appropriate learning with Conceptual Attainment method, and appropriate learning to improve science process skills. Second validation was done by teacher. Through this validation produced draft III.</p> <p><b>b. Limited Test</b> Worksheet as the learning product and supporting instrument such as lesson plan, pretest posttest, and student questionnaire which be produced from draft III revision would be tested in small group (limited). Suggestions, corrections and revisions from limited test would be used as revision for bigger group (field test).</p> <p><b>c. Field Test</b> The aim of this test was to know worksheet feasibility and learning method effectiveness in bigger group. Revision result based on field test and student questionnaire would produce final product.</p>
<p><b>4. Disseminate</b> This step aim was to share the development product in bigger group than the field test, such as other classes, other schools, or other teachers. Instruments which used in this research were learning instrument and data collecting instrument.</p>	<p><b>1. Learning Instrument</b></p> <p><b>a. Lesson Plan</b> Lesson plan was used as guidelines for teacher in learning process so the materials which given were appropriate with learning aims. This was validated by lecturer and teacher so it could be appropriate with learning to improve concept understanding and science process skills.</p> <p><b>b. Conceptual Attainment Worksheet</b> This worksheet was used in learning process. The contents were expected to improve student concept understanding and science process skills.</p>

Procedure	Steps
	<p><b>2. Data Collecting Instrument</b></p> <p><b>a. Observation Sheets of Learning Process</b> This observation sheets were made to determine student first condition in learning before giving treatment, which concluded level thinking skills, activation in classroom and response to learning that given by the teacher. Through this observation result could be developed learning instrument which be appropriate with students condition.</p> <p><b>b. Validation Questionnaire</b> This questionnaire was used to get worksheet feasibility data in language structure and design, appropriate learning with Conceptual Attainment method, and appropriate learning to improve science process skills. Furthermore, it was used to get lesson plan feasibility data in appropriate learning to improve concept understanding and science process skills.</p> <p><b>c. Student Responses Questionnaire</b> This questionnaire consisted of positive and negative statements which be arranged randomly to know student responses of Conceptual Attainment worksheet.</p> <p><b>d. Pre-test and Post-test</b> This instruments were used to measure student cognitive ability after using Conceptual Attainment worksheet.</p> <p><b>e. Observation Sheets of Science Process Skills</b> This observation sheets were used to know the improvement of science process skills for each students when using Conceptual Attainment worksheet.</p>

Analysis data concluded learning media feasibility from lecturer and teacher scoring, instrument reliability, student responses questionnaire, pretest posttest data, and observation result of science process skills.

1. Learning Media Feasibility from Lecturer and Teacher Scoring

a. Calculating average score from each assessment component aspects with formula:

$$\bar{x} = \frac{\sum x}{n}$$

Notes:

$\bar{x}$  : Average score

$n$  : Total assessors

$\sum x$  : Score total for each assessment aspects

b. Converting score to five grades scale

1. Calculating ideal average score ( $\bar{X}_i$ )
2. Calculating ideal standard deviation ( $sb_i$ )
3. Determining assessment criteria:

**Table 2.** Ideal Assessment Criteria

Quantitative Scores Range	Category
$\bar{X}_i + 1.8sb_i < X$	Very Good
$\bar{X}_i + 0.6sb_i < X \leq \bar{X}_i + 1.8sb_i$	Good
$\bar{X}_i - 0.6sb_i < X \leq \bar{X}_i + 0.6sb_i$	Enough
$\bar{X}_i - 1.8sb_i < X \leq \bar{X}_i - 0.6sb_i$	Less
$X \leq \bar{X}_i - 1.8sb_i$	Very Less

(Widoyoko, 2009)

2. Instrument Reliability

Instrument reliability calculation used Percentage of Agreement. The formula was:

$$\text{Percentage Agreement} = \left( 1 - \frac{A - B}{A + B} \right) \times 100\%$$

Note:

A : High score

B : Low score

Good instrument happen when reliability coefficient more than or equal with 0.75 or 75% (Borich, 1994).

### 3. Student Responses Questionnaire

Analysis steps of student responses questionnaire were: (a) Changing positive and negative statement scale into 1-4 scale, for positive statement: strongly disagree=1, disagree=2, agree=3, strongly agree=4, and for negative statement: strongly disagree=4, disagree=3, agree=2, strongly agree=1; (b) Discarding unreliable scale between positive and negative statement from each students in same aspect; (c) Calculating total students who answer in every aspects from scale 4 until 1; and (d) Calculating total students percentage (%) who answer in every scale (from 4 until 1) for all aspects.

### 4. Pretest Posttest Data

Pretest posttest data in this research was used to find the improvement of student concept understanding. It was expressed by the value of gain. Normalized gain (g) was used to know the gain of each students.

$$(g) = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

Then the calculation result of normalized gain was converted into normalized gain criteria:

**Table 3.** Normalized Gain Interpretation

Standard Gain Score (g)	Criteria
$0.70 < (g)$	High
$0.30 \leq (g) \leq 0.70$	Medium
$(g) < 0.30$	Low

(Hake, 1999)

### 5. Observation Result of Science Process Skills

Steps to analyze the observation result of science process skills were: (a) Calculating average score between two observers; (b) Summing and averaging each students score in every science process skill aspects; (c) Changing student average quantitative score to qualitative score with five scales. Conversion criteria of the score can be seen on Table 2; (d) Calculating average score for each science process skills aspects in experiment 1, 2, 3, 4, 5, and 6; (e) Calculating science process skill improvement by using normalized gain; (f)

Grouping the gain score to high, medium, or low. Normalized gain criteria can be seen on Table 3; (g) Calculating the reliability of each aspects in science process skills observation sheets.

## RESULTS AND DISCUSSION

### 1. Worksheet Validity Result

Validation result was used to know the worksheet feasibility. Quantitative score as the result of validation then converted to qualitative category for each aspects. Worksheet quality was known from lecturer and teacher average score.

#### a. Worksheet Validation by Lecturer

Lecturer score result in language structure and design 32, appropriate learning with conceptual attainment method 11, and learning to improve science process skills 21, which all aspects got the best category.

#### b. Worksheet Validation by Teacher

Teacher score result in language structure and design 34, appropriate learning with conceptual attainment method 10, and learning to improve science process skills 19, two aspects got the best category and for appropriate learning with conceptual attainment method just got good category.

### 2. Lesson Plan Validity Result

Validation aspects consisted of lesson plan identity, Core Competences, Basic Competences, learning indicators, learning material, learning process, student assessment system, lesson plan language, media/instrument, language, and learning references. This validation result got one enough category, two good categories, and five best categories, which can be seen in Table 4.

**Table 4.** Lesson Plan Validity by Lecturer and Teacher

Aspects	Average Quantitative Score	Qualitative Score
Identity	3	Very Good
Core Competences and Basic Competences	3	Very Good
Learning Indicators	3	Very Good
Learning Material	2.5	Good
Learning Process	3	Very Good

Assessment	3	Very Good
Language	2	Enough
Media/instrument, language and learning references	2.5	Good

Based on the results of this study, the reliability using Percentage of Agreement of lesson plan can be seen on Table 5.

**Table 5.** Lesson Plan Reliability

Aspects	PA (%)	Criteria
Identity	100	Reliable
Core Competences and Basic Competences	100	Reliable
Learning Indicators	100	Reliable
Learning Material	80	Reliable
Learning Process	100	Reliable
Assessment	100	Reliable
Language	100	Reliable
Media/instrument, language and learning references	80	Reliable

### 3. Development Test

Second revision worksheet was used as product development test. The test was given to XI class students SMA Negeri 1 Magelang. There were two types of test, limited test and field test. Each group test consisted of 3 meetings, at first meeting students solved pretest problems and did experiment 1 and 2, at second meeting students did experiment 3, 4, and 5, and the last meeting students did experiment 6 and solved posttest problems.

#### a. Limited Test Result

##### 1) Cognitive Assessment Result

Cognitive assessment from pretest and posttest result was used to know the improvement of student concept understanding. Data for cognitive assessment result of limited test:

**Table 6.** Pretest and Posttest Result

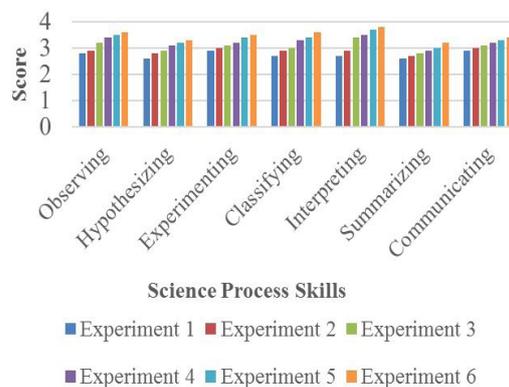
Pretest Score		Posttest Score		Average Gain
Average	SD	Average	SD	
39	10.90	74	8.83	0.56 (medium category)

From the calculation on Table 6, average gain for limited test class was 0.56 or in medium category. If maximal improvement is 100%, so this improvement of student concept understanding had been significant because more than 50%.

Atmojo (2012) stated that conceptual understanding would be better if the students involved actively in the learning process. The improvement would be better than the students who passive or just listening to the teacher explanation. Based on the study of (Hussain & Akhtar, 2013; Ates & Eryilmaz, 2011; Jones et al., 2003), active learning that included student learning interaction would produce significant result of student achievement.

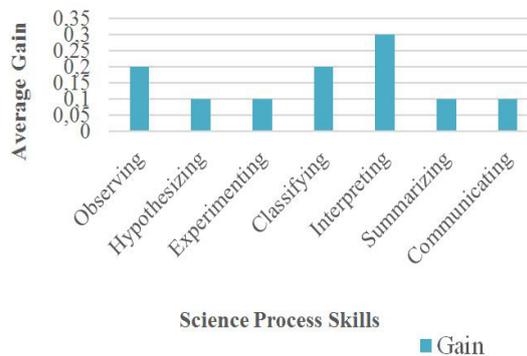
### 2. Observation Result of Science Process Skills

Science process skills data was gotten from observation to student as long as using the worksheet. Diagram of science process skills in limited test.



**Figure 1.** Science Process Skills Diagram

The average improvement each science process skills aspects from experiment 1 until 6:



**Figure 2.** Gain Diagram of Science Process Skills

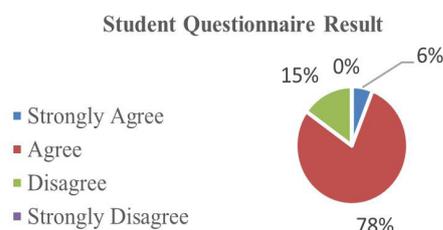
From Figure 2, the lowest aspects were seen on hypothesizing, experimenting, summarizing, and communicating. Based on the study of (Hodosyova et al., 2014), from three science process skills: hypothesizing, interpreting, and summarizing, the hypothesizing aspect got the lowest score (33%) because of the limitation in process of collecting data. In this study, hypothesizing aspect also got the lowest score of average gain 0.1 but the score was same with experimenting, summarizing, and communicating. Reliability of science process skill aspects in limited test can be seen on Table 7.

**Table 7.** Reliability of Science Process Skill Aspects

Aspect	PA (%)	Criteria
Observing	98.1	Reliable
Making Hypotheses	98.9	Reliable
Doing Experiment	98.8	Reliable
Classifying Data	99.3	Reliable
Interpreting Data	98.0	Reliable
Summarizing	99.0	Reliable
Communicating	98.5	Reliable

3. Student Questionnaire Result

It was an assessment result for the developed worksheet. Student respond propensity to all worksheet assessment aspects can be seen at pie diagram:



**Figure 3.** Pie Diagram of Student Questionnaire Result

Percentage of student who strongly agree to worksheet in limited test was 6%, agree 78%, disagree 15%, and strongly disagree 0%. Student response propensity to the developed worksheet was agree with percentage 78%, which meant that conceptual attainment worksheet was proper to be used in learning process.

b. Field Test Result

1. Cognitive Assessments Result

The result of pretest and posttest in field test can be seen on Table 8.

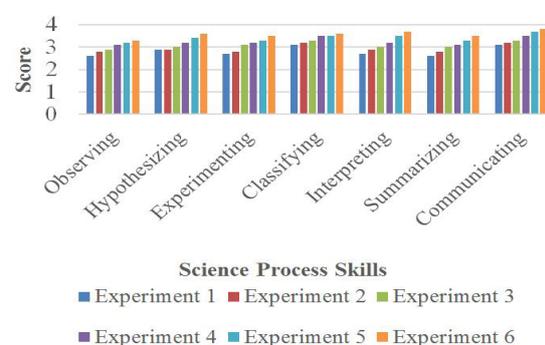
**Table 8.** Pretest and Posttest Result

Pretest Score		Posttest Score		Average Gain
Average	SD	Average	SD	
42	12.27	71	11.09	0.50 (medium category)

Based on calculation, average gain for field test class was 0.50 or in medium category. It meant that conceptual attainment worksheet can be used to improve student concept understanding although it haven't improved into high category.

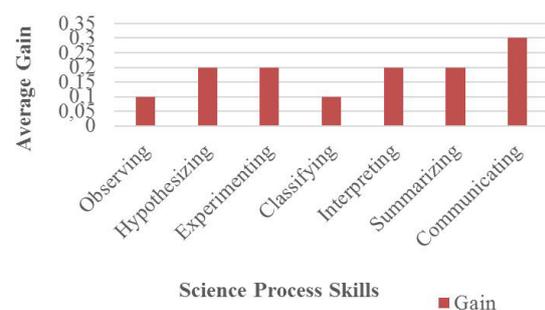
2. Observation Result of Science Process Skills

Science process skills result of students in field test can be seen at Figure 4:



**Figure 4.** Science Process Skills Diagram

The average improvement each science process skills aspects from experiment 1 until 6 based on normalized gain (g):



**Figure 5.** Gain Diagram of Science Process Skills

The diagram explained that 6 science process skills aspects improved although in low category and just an aspect got medium category, which was communicating aspect with average gain (g) 0.3. Low category improvement was on observation and classify data to table aspect with average gain 0.1. This meant that conceptual attainment worksheet could be used to imp-

rove science process skills of students although it didn't significant with range from 0.1-0.3. Based on the study of (Ozlem & Cakiroglu, 2011), student attitude didn't get significant result if the treatment just given as long as short period (3 weeks). This study also conducted as long as 3 meeting (2 weeks) so the improvement of science process skills didn't have significant result. The result would be significant if conducted more than 12-13 weeks.

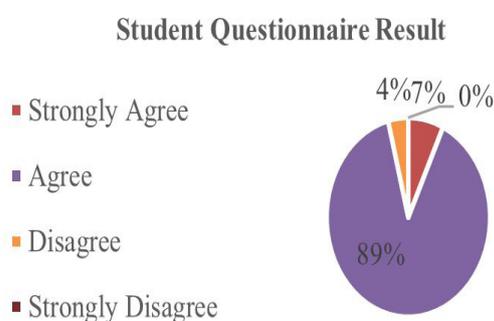
Reliability of science process skill aspects in limited test can be seen on Table 9.

**Table 9.** Reliability of Science Process Skill Aspects

No	Aspect	PA (%)	Criteria
1	Observing	98.3	Reliable
2	Making Hypotheses	99.2	Reliable
3	Doing Experiment	98.6	Reliable
4	Classifying Data	98.9	Reliable
5	Interpreting Data	98.3	Reliable
6	Summarizing	98.8	Reliable
7	Communicating	98.1	Reliable

### 3. Student Questionnaire Result

Student response propensity to all assessment aspects of the worksheet can be seen on Figure 6.



**Figure 6.** Pie Diagram of Student Questionnaire Result

Percentage of student who strongly agree to worksheet in field test was 7%, agree 89%, disagree 4%, and strongly disagree 0%. Student respond propensity to the developed worksheet was agree with percentage 89%, which meant that conceptual attainment worksheet was proper to be used in learning process.

## CONCLUSION

Based on results and discussion, it can be concluded that: (1) Conceptual attainment worksheet was proper to be used based on Percentage Agreement score in language structure and design 96.97%, appropriate learning with conceptual attainment method 95.24%, and learning to increase science process skills 95%, which all aspects got the best category. Almost students agreed to the worksheet with presentation 78% for limited test and 89% for field test; (2) Concept understanding improvement based on normalized gain (g) was 0.56 for limited test and 0.50 for field test, which both of them got medium category; (3) Science process skills improvement wasn't significant for all the test with range 0.1-0.3.

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## ANALYSIS OF KNOWLEDGE, UNDERSTANDING, AND SKILLS OF PHYSICS TEACHERS OF STATE SENIOR HIGH SCHOOLS IN DEVELOPING AND ANALYZING TEST ITEMS

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### ABSTRACT

This study is aimed to determine the level of knowledge and understanding of physics teachers to the evaluation of learning and to describe the physics teachers' skills in constructing and analyzing items. This type of research is quantitative descriptive, the technique of data collection is done by survey method using a developed questionnaire instruments. The population in this study is all physics teachers of Senior High School throughout the city of Banda Aceh. Those became the samples were 32 physics teachers of Senior High School randomly selected. The data obtained were analyzed descriptively. The results showed that only physics teachers of SMAN 4, SMAN 7, SMAN 8, SMAN 10 and SMAN 13 Banda Aceh who have very high category of knowledge and understanding level of the learning evaluation and the skills of physics teachers of Senior High School in Banda Aceh in constructing and analyzing the test items have not been satisfactory.

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**Keywords:** evaluation; knowlegde; understanding; skills

### INTRODUCTION

Teachers are professional educators with the primary task of educating, teaching, guiding, directing, training, assessing, and evaluating students (Kartomo, 2016). Professional teachers will be reflected in the performance of duties characterized by expertise, both in materials and methods (Shabir, 2015).

Professional ability is a capability that must be possessed by a person to perform tasks and activities in the field of science that must be deliberately studied and then applied to the public interest (Agusniar, 2015). Thus, professional teachers are teachers who have the ability to plan learning, implement learning, evaluate learning and have a high responsibility in improving student learning achievement. Competence will be

realized in the form of mastery of professional deeds in performing its function as a teacher (Widodo, 2012).

Ability in conducting learning evaluation is one of the professional competence of teachers. There is no learning without evaluation because evaluation is the process of determining the quality of learning outcomes, or the process to determine the level of achievement of learning goals by learners (Syafrudin, 2002). Assessment and evaluation of student learning outcomes is one of the abilities that must be possessed by a teacher. Osnal et al. (2016) suggests that one professional teacher in accordance with the main task and function is skilled in presenting teaching materials in the classroom and outside the classroom, as well as professionals in evaluating learning outcomes. Assessment of learning outcomes of learners is one of the abilities that must be owned by a teacher that is included in pedagogic competence (Camellia & Chotimah, 2012).

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According to Azim & Khan (2012), assessment is a conventional activity, which is practiced in schools on a day-to-day basis. It is also a process, which helps in developing students' learning. It provides the teacher with an opportunity to review their own teaching and to enhance students' learning. Gaytan & McEwen (2007) argued that assessment is an important way to respond to student accountability. Teachers should set assessment goals, measure criteria, and intended outcomes before meaningful assessment methods can be achieved. According to Widoyoko (2013), assessment can be interpreted as an activity to interpret data measurement results. Thus a teacher should be based on measurement and assessment data in evaluating the learning.

Evaluations can encourage students to be more active in learning continuously, and can also encourage teachers to further improve the quality of the learning process and encourage schools to further improve the facilities and quality of school management. Therefore, in the learning, teachers are not only required to teach well, but also to evaluate well. To measure the success of learning, teacher requires skills in evaluating (Handayani, 2014). The ability to evaluate learning outcomes is an absolute basic ability that teachers must possess.

The ability of teachers in the mastery of evaluation techniques is shown by the ability to design evaluation patterns, develop test instruments, be able to analyze problems, compile problems in various cognitive levels of Bloom, able to do objective scoring, see the results obtained by students, and select appropriate action as an effort to follow up assessment results/measurements. According to Afriyani (2013), in implementing the evaluation of learning, there are some activities undertaken by the teacher, namely: planning of writing a problem in which the teacher makes a grid problem so that the questions are arranged more directed in accordance with the materials and teaching purposes, then carry out tests, and process the results of the test then the teacher can interpret the test results into the scoring book, the inputted scores are in accordance with the value obtained by students.

Result of National Examination (UN) year 2015/2016 for physics lesson shows that physics student achievement of SMAN in Banda Aceh city is relatively low. One of the causes that may make the students fail in the UN is the level of questions. The level of UN questions consists of high-level questions (C4, C5, and C6), while the teacher's level of questions is low level (C1, C2, and C3). Based on interviews, several physics te-

achers at SMAN Banda Aceh who are currently studying S2 at the Graduate School of Unsyiah also acknowledge their weaknesses in evaluating their students, especially in compiling the questions. Furthermore, the results of Yusrizal et al. (2011) also showed that the component of the students' learning achievement result from the certified teachers of Physics, Chemistry and Biology of SMAN Banda Aceh is still low.

Based on the description, this study aims to determine the ability of physics teachers of state Senior High Schools in Banda Aceh to the evaluation of learning. In particular, this study aims to determine the level of knowledge, understanding and skills to compose and analyze items by physics teachers of state Senior High Schools in Banda Aceh. The benefit of this research is to be input to physics teachers and head of Banda Aceh State Senior High School, and Department of Education in Aceh Province.

Humans are different from each other. It results in differences in work or learning achievement. To know the existence of differences in student achievement, we required a tool that can measure the state of the individual, and gauges which are called tests. The success of the evaluation of learning outcomes in schools is highly dependent on the quality of test instruments used. Sulistyorini et al. (2013) suggests that the achievement of cognitive competence of students in the learning process can be seen from how students solve the problem of the given learning materials which are usually manifested in the form of tests.

A test is a systematic procedure created in the form of standardized tasks assigned to individuals or groups to be worked on, answered or responded to, either in written form, oral or deed (Matondang, 2009). The test of learning outcomes is one way to trace the abilities that students have had after following the teaching and learning process for a certain time (Lababa, 2008). Evaluation is the stage after the teaching-learning process is implemented to complete the teaching-learning cycle as an interactive educational process, ranging from goal formulation to the provision of interaction support facilities. According to Aji and Winarno (2016), the evaluation process is one of the teachers' task that will determine the direction of the next learning process.

The picture of high and low learning outcomes which is obtained by using a bad test is not a true description of student achievement. The test is a number of questions that have correct or false answers, questions that require answers, questions to be answered with the objective of

measuring a person's capability level or uncovering certain aspects of the tested person (Munadi, 2011). The main purpose of asking students questions is to know whether the material taught has been mastered by the students completely or not. According to Harmawati et al. (2014) one of the factors that must be addressed is to improve the quality of the tests on the items used in each evaluation.

A professional teacher must have competence in constructing and analyzing problems or tests because the tests are used as a tool to measure learning attainment. Teachers play an important role in the preparation of evaluation in the form of tests. Hence, every teacher is required to have a big responsibility to plan and carry out evaluation (Suryawati & Yulfikar, 2012). According to Saikhoni (2015), one of the requirements of a good test is that the test must be valid, the test should precisely measure something to be measured. The more qualified the assessment of learning, the better the teacher's understanding of the weaknesses and strengths of students in learning certain material (Kusairi, 2012).

Learning outcomes are achievements that can be shown in the form of number symbols by students after following the learning process. Evaluation can be used as a tool to know the extent to which the learning objectives have been achieved. According to Badriyah (2014), evaluation is a tool used to determine the understanding the mastery of learners to the material that has been delivered. Assessment basically aims to obtain information about the development process and learning outcomes of learners and the results of teachers' teaching (Osnal et al., 2016). Thus, assessment and evaluation are basically aimed at obtaining information about the development of the learning process and outcomes of students and the results of teachers' teaching.

## METHODS

This research uses descriptive quantitative approach with development research type. This study was conducted from July to October 2016. The research activities followed the steps (1) develop a questionnaire instrument to assess teachers' knowledge and understanding of learning evaluation and the ability to develop and analyze problems; (2) conduct surveys to teachers of state senior high schools in Banda Aceh. Instruments for assessing knowledge, comprehension and problem-solving skills are developed with refe-

rence to the theory of developing the instrument of a typical performance (Gable 1986; Djaali & Muljono, 2008). Instrument validity is formed by using correlation formula of product moment by Pearson, that is correlation between grains with its total (Pujihastuti, 2010). Validity test results obtained 38 valid items. Reliability testing conducted by Alpha Cronbach formula (Son et al., 2014) obtained the reliability coefficient of the instrument of 0.93.

To give an interpretation of the results of the teacher's level of knowledge analysis of learning evaluation, categorization is used according to Azwar (2012), that is:

$X \leq 35$	Knowledge of learning evaluation Very Low
$35 < X \leq 49$	Knowledge of learning evaluation Low
$49 < X \leq 63$	Knowledge of learning evaluation Medium
$63 < X \leq 77$	Knowledge of learning evaluation High
$X > 77$	Knowledge of learning evaluation Very High

To give an interpretation of the results of the teacher's level of understanding analysis of the learning evaluation, the following categorization is used.

$X \leq 32,5$	Understanding of learning evaluation Very Low
$32,5 < X \leq 45,5$	Understanding of learning evaluation Low
$45,5 < X \leq 58,5$	Understanding of learning evaluation Medium
$58,5 < X \leq 71,5$	Understanding of learning evaluation High
$X > 71,5$	Understanding of learning evaluation Very High

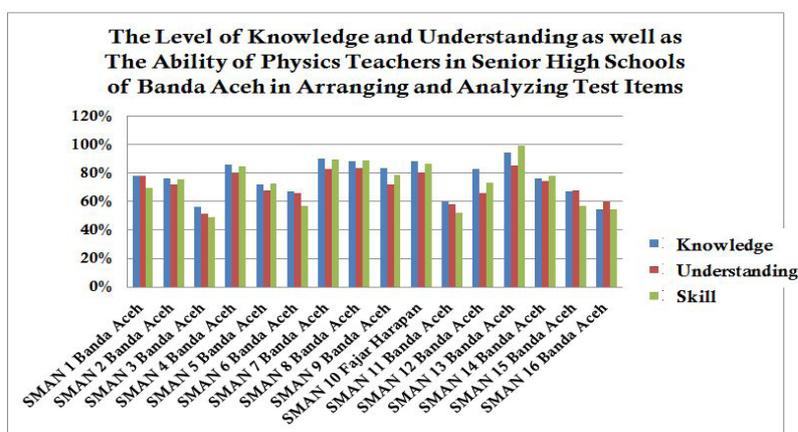
While in giving interpretation to result of skill level in preparing and analyzing test items, the following categorization is used.

$X \leq 27,5$	Skill in arranging and analyzing problems Very Low
$27,5 < X \leq 38,5$	Skill in arranging and analyzing problems Low
$38,5 < X \leq 49,5$	Skill in arranging and analyzing problems Medium
$49,5 < X \leq 60,5$	Skill in arranging and analyzing problems High
$X > 60,5$	Skill in arranging and analyzing problems Very High

## RESULTS AND DISCUSSION

The result of analyzing the level of knowledge, understanding, and ability of physics teacher in preparing and analyzing data is presented in Figure 1. The detailed categories of knowledge, understanding, and skills of Physics teachers in compiling and analyzing the problems of each school can be seen in Table 1.

The results of the analysis reveals that 16 state senior high schools in Banda Aceh, it can be seen that only five schools achieved the category of ‘very high’ in terms of knowledge, understanding and skills to compile & analyze the problem. The five SMANs are SMAN 4, SMAN 7, SMAN 8, SMAN 10 and SMAN 13 respectively.



**Figure 1.** The Level of Knowledge, Understanding, and Skills of SMAN Physics Teachers in Banda Aceh City in Preparing and Analyzing Problems

There are three SMAs namely SMAN 1, SMAN 2, and SMAN 5 that achieve high category in terms of knowledge, understanding and skills of teachers in preparing and analyzing the problems. Furthermore, it is also revealed that physics teachers from three high schools (SMAN 9, SMAN 12, and SMAN 14) whose level of knowledge about learning evaluation is very high achieved high category in terms of the level of

understanding and skill to arrange & analyze the problems.

The result also revealed that there are two high schools that the level of knowledge and understanding of learning evaluation is in the high category, but the skills of composing & analyzing the problem is in the medium category. The schools are SMAN 6 and SMAN 15.

**Table 1.** Percentages and Categories of Knowledge, Understanding, and Skill Levels of SMAN Physics Teacher in Preparing and Analyzing the Problems

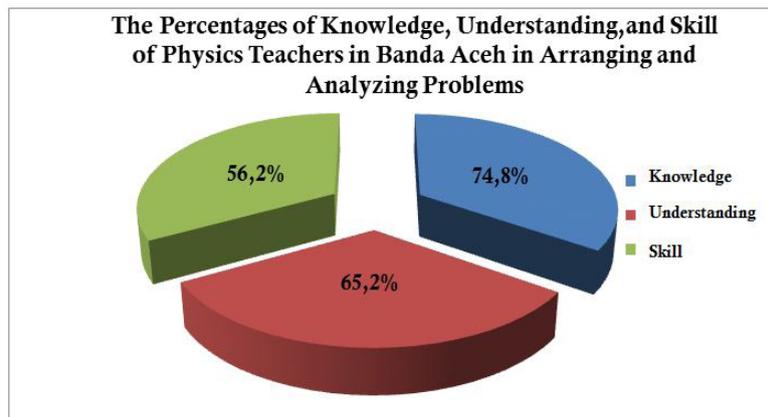
School Name	Knowledge		Understanding		Skill	
	%	Category	%	Category	%	Category
SMAN 1	76,5	high	71	high	53,5	high
SMAN 2	75	high	65,5	high	58,5	high
SMAN 3	55,3	medium	47	medium	38	rendah
SMAN 4	84	very high	73	very high	65,5	very high
SMAN 5	70,5	high	62	high	56	high

SMAN 6	66	high	60	high	44	medium
SMAN 7	88,5	very high	75,5	very high	69	very high
SMAN 8	86,5	very high	76	very high	68,5	very high
SMAN 9	82	very high	65,5	high	60,5	high
SMAN 10	86,5	very high	73,5	very high	66,5	very high
SMAN 11	58,5	medium	53	medium	40	medium
SMAN 12	81,3	very high	60,3	high	56,3	high
SMAN 13	92,5	very high	77,5	very high	76,5	very high
SMAN 14	75	very high	68	high	60	high
SMAN 15	66	high	61,5	high	44	medium
SMAN 16	53,4	medium	54,5	medium	42	medium

Furthermore, it is known also that the physics teachers of SMAN 16 still have the level of knowledge, understanding, and skills to prepare & analyze the problem in the medium category. The physics teachers of SMAN 3 achieved the level of knowledge and understanding of learning evaluation which is still medium, and the skill of composing & analyzing the problem which is in the low category. SMAN 3 is included into one of the best and favorite SMAN in Banda Aceh city. In SMAN 2, the physics teachers' level of know-

ledge, understanding and skills in preparing and analyzing items are in the high category. Physics teachers of SMAN 5 achieved the level of knowledge, understanding and skills in preparing and analyzing items which is in the medium category.

The percentages of knowledge and understanding of physics teacher to learning evaluation are 74.8% and 65.2% respectively. The percentage of skills of the physics teacher to compile and analyze the items is 56.2%. It can be visually seen in Figure 2.



**Figure 2.** The Percentages of Knowledge, Understanding, and Skill of Physics Teachers in Banda Aceh in Arranging and Analyzing Problems

Generally, the level of knowledge and understanding and skills of physics teachers of State Senior High School in Banda Aceh in preparing and analyzing the items has not been satisfactory. Physics teachers do not have the ability and skill to optimize the test properly and quality. This results in weakness in students who will face tests both at national and international levels. Munasco (2013) suggested that teacher quality factor (qualification) is considered the most do-

minant. It also influences the physics learning outcomes and forms of test used. This brings impact on students' learning outcomes to be less satisfactory. Professional teachers in accordance with the main tasks and functions are: (1) Able to prepare the lesson plans; (2) Able to construct quality test results; (3) Skilled in presenting teaching materials in class and outside the classroom, professional in evaluating learning outcomes (Os-nal et al, 2016).

## CONCLUSION

Based on the analysis, it can be concluded that only physics teachers from SMAN 4, SMAN 7, SMAN 8, SMAN 10 and SMAN 13 of Banda Aceh have a level of knowledge and understanding of learning evaluation which is categorized into very high. The skills of physics teachers of SMAN Banda Aceh in preparing and analyzing the items have not been satisfactory.

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## THE IMPLEMENTATION OF CONSTRUCTIVISM-BASED STUDENT WORKSHEETS WITHIN THE THEME 'THE PREVENTION OF LAND AND FOREST FIRE' IN SCIENCE EDUCATION FOR SEVENTH GRADERS IN RIAU

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### ABSTRACT

The issues of land and forest fire require a comprehensive effort, one of which is through the dissemination of educational values, such as science education. This verification study aims to examine the truth of the stage competence on the constructivism approach of the advanced test on student worksheet 1 and 2 and compare it with the test results 2 on the theme of forest and land fire and peat swamp ecosystem as well as global warming and its impact. The study was conducted in the laboratory of Biology department, Faculty of Teacher Training and Education, Universitas Riau and SMPN 1 Bungaraya in September-December 2016. This type of research is verification research of advanced test results with test results on 2 sets of developed student worksheet. The data were collected from student worksheet. The results from this study indicate that students' competence in constructing ideas through constructivism approach is 'good' at student worksheet 1 (mean score=3.27) and 'very good' at student worksheet 2 (mean score=3.43). The data also show that there was a consistency between the advanced test to the experimental test II. This study concludes that student worksheet 1 and student worksheet 2 can improve the students' competence in building their knowledge on the topic of forest and land fires, and both worksheets (student worksheet 1 and 2) are eligible to be used as a reference for teaching science subject for Grade VII.

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**Keywords:** student worksheets; constructivism; approach

### INTRODUCTION

The Department of Forestry notes that the land and forest fire in Indonesia has reached 38,000-40,000 hectares in 2015. Peat swamp forests are vulnerable natural resources prone to environmental changes. Due to this vulnerability, this ecosystem should be handled carefully to prevent its function deteriorating from some causes, such as one of which, land and forest fire. To reduce the number of land and forest fire, related stakeholders need to conduct special policy enforcement interventions against the perpetrators of land burners (Darmawan et al., 2016).

Land and forest fire is related to the exploitation of peatlands for establishing oil palm plantations, followed by the addition of canals. These canals serve as water transportation routes to facilitate the transport of logged timber trees from forests or peatlands. Additionally, it also serves as means transport for palm seedlings and other necessities that are difficult to transport through peat swamps. These canals cut the water flow to the creeks thus cause drainage of watershed areas. These could be the trigger for peatland fires in watershed and for the decline of fish diversity (Yustina, 2016).

Some efforts to prevent and avoid the land and forest fire have been made, yet the optimal results have not been achieved. One of the causes for the unsuccessfulness of the efforts is the lack of people knowledge and understanding on

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the dangers of land and forest fire and its impacts on the peat swamp ecosystem. Therefore, it needs more comprehensive efforts to instill the values of knowledge in order to prevent land and forest fire.

The cultivation of knowledge values, including the knowledge about land and forest fire is basically an inherent principal of educational process. Education is a means to shape perceptions, attitudes and human behavior. A positive attitude toward the environment can be effectively instilled through constructivism learning approach in secondary schools (Yustina et al., 2010). Therefore, optimizing the role of secondary education in developing the knowledge and understanding the environmental issues (e.g. land and forest fire) become very strategic to be student-centered. Sumarni et al. (2016) believed that student-centered learning has virtues and benefits to students to develop three learning domains namely cognitive, affective and psychomotor domains. It begins with practical organized work and plays an important role in the creativity associated with daily life activities to build students' knowledge and skills.

Constructivism is a combination of ideal behavior and cognitive. It describes how students understand the materials and also how teacher can deliver the material effectively. Constructivism as an educational theory requires teachers to consider what students know and allows students to develop their knowledge into practice (Amineh & Asl, 2015). Constructivism presents an alternative paradigm against objectivism in a way that investigation depends on how risk is built and handled in particular historical, socio-cultural and political contexts (Chipangura & Waldtm, 2016).

Ministerial regulation No. 19 Year 2005 on Education based on Local Excellence stated that educators can develop teaching instruments and materials according to local uniqueness or needs by integrating them into particular subjects. Contextual environmental phenomena on the environmental management and diversity are very useful for teaching about environment and are to be applied in the students' daily life (Priyanto et al., 2013).

Rosnita (2016) also argues that the basic concept of science can be developed through scientific and critical thinking works. This can be done through some stimulating activities such as practicum in a well-equipped laboratory. Another strategy to develop students' curiosity is through useful and contextual learning materials. In the

learning activities, students can be guided by using student worksheets.

Student worksheets within the theme 'preventing the land and forest fire' were integrated to three basic competences in science education for secondary schools. The three competences included in the worksheets are: basic competence 3.8 about ecosystem; 3.9 about environmental pollution; and 3.10 about global warming. The integration of materials on land and forest fire into student worksheets was considered on the basis that student worksheets have some advantages, such as facilitating the learners more effectively, helping the learners be more independent, and helping the learners to do written tasks.

Previous study has conducted a limited experiment on the development of student worksheets within the theme 'Preventing Land and Forest Fire' (Fitri, 2016). A verification study aims to verify this result by conducting a post hoc test to ensure the students' experience in using the worksheets. Prior to collecting data with the students, the study collected science teachers' responses in Bungaraya sub district on the content, design, and the pedagogy of the worksheets based on the constructivism approach. Finally, the present study revises the students worksheets to complement them (Yustina et al., 2016).

Verification research is conducted to test the truth of existing science either in the form of concepts, principles, procedures, propositions or practice of education itself. The research data obtained is used to prove the existence of doubt on information or educational problems (Arifin, 2014).

This verification study aims at testing the truth on the impression of competence process in each stages of scientific development through constructivism approach. The stages are: developing ideas, structuring ideas, application, and reflection. The data was collected from student worksheets for seventh grade students at SMPN 1 Bungaraya, Siak regency.

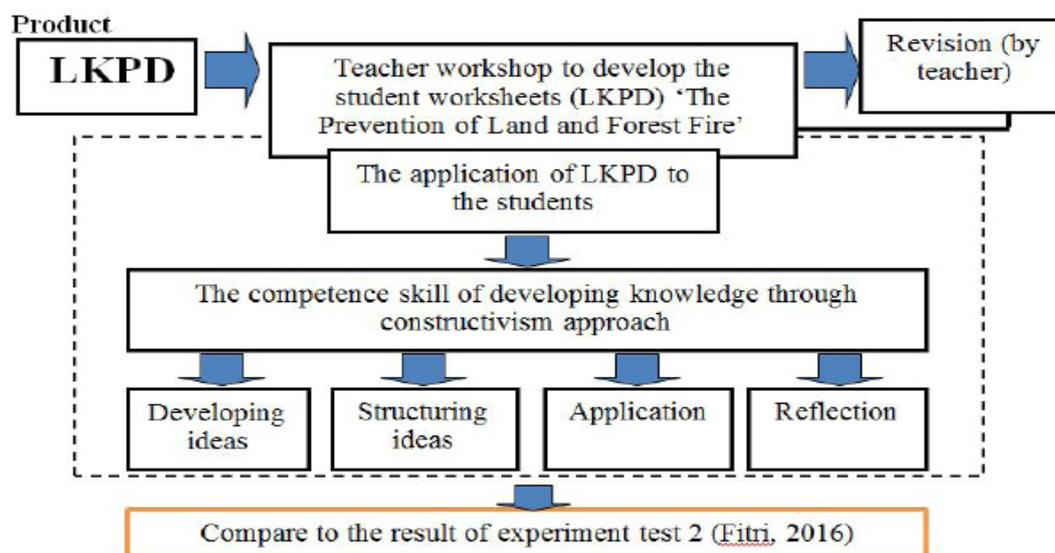
## METHODS

This post hoc research investigated the use of students worksheets with the theme 'the prevention of land and forest fire' at SMPN 1 Bungaraya during August to December 2016. The study employed purposive sampling (Darmadi, 2014), and involved 60 students from Grade VII SMPN 1 Bungaraya. Two sets of student worksheets were used for the post hoc test. Student worksheet 1 with the theme 'types of ecosystems' and

student worksheet 2 with the theme 'global warming, effects, and prevention'. Data was collected from the students' responses on the worksheets. The students' competence on constructivism stages is classified into: generating ideas, structuring ideas, application, and reflection. The score was accumulated, drawn the percentage, compared to the experiment 2 result (Fitri, 2016), and then analyzed descriptively. The stages in this verification study are presented in Figure 1.

The description of the activities in the Figure 1 is as follows: (a) Together with the instructor of the training, the trainees conducted evaluation and revision of student worksheet format as a part of the training activities of student worksheet development on the prevention of land and forest fire to science teachers of Junior High School in

Siak District. The revision they made was like an addition of activity schedule and assessment column at the end of section; (b) In the following week, this revised student worksheet was further applied by the teachers for further examination to Bungaraya Junior High School students; (c) In the third week, student worksheet results of this trial were analyzed to see the students' competence in terms of their skills of building knowledge through constructivism, which consisted of stages: idea-generating, idea-structuring, application and reflection; and (d) The result of student worksheet data analysis was shown in table form, and the mean value at each constructivism stage was shown as bar graph, then compared with result of trial II (Fitri, 2016) for verification test.



**Figure 1.** The Flowchart of Study: The Use of Students Worksheets Based on Constructivism Approach in Grade VII of SMPN 1 Bungaraya

Figure 1 shows that on the activity of student worksheet with theme of preventing forest fire, the science teachers in Siak carried out an evaluation of student worksheet format. In the following week, the revised format was implemented in SMP Bungaraya. In the third week, the students' competence is analyzed by using constructivism. The result of data analysis was presented in table and chart that it is compared to the Trial II for verification.

## RESULTS AND DISCUSSION

Upon the collection of students' responses from the post hoc test, the responses were analyzed based on the constructivism approach which was the basis principle of developing the student worksheet. The post test of student worksheet completed by students was then submitted, so

the teachers can assess the stages of constructivism in the student worksheet: developing ideas, structuring ideas, application, and reflection.

The worksheets under investigation are student worksheet 1 with the theme 'types of ecosystems' (Table 1) and student worksheet 2 with the theme 'global warming, effects, and prevention' (Table 2). Based on indicators of constructivism approach, each student worksheet obtained mean score of 3.27 and 3.43 within the category of 'good'. The highest score from both student worksheet is found at the stage of 'developing ideas' with mean score of 3.67 (very good). In this stage of developing ideas, students are able to explain what they already know about the 'types of ecosystems' in student worksheet 1 and 'factors causing global warming and the impacts of global warming' in student worksheet 2.

There were 60 Students who took the advanced test. Their average score is 3.27 (good category). The results of the assessment of constructivism stages in student worksheet show that the average score for the generating ideas is 3.67 (very good category) with the following details: 45 students with score 4 (very good category), 10 students with score 3 (good category) 2 with score 2 (enough category). While the average score for structuring ideas skills is 3.55

(very good category), with following details: 36 students with score 4, 21 students with score 3 and 3 students with score 2. Then, the average score for application skills is 3.00 (good category), with details: 24 students with score 4, 20 students with score 3, each of 8 students with scores 2 and 1. Finally, the average value for reflection is 2.87 (good category), with the details: 22 students with score 4, 18 students with score 3, and each 10 students with score 2 and 1.

**Table 1.** The Result of Student Worksheet I, Theme 'Type of ecosystems'

Constructivism Stages	Score				N (Students)	Mean	Category
	4	3	2	1			
Developing ideas	45	10	5	-	60	3.67	VG
Structuring ideas	36	21	3	-	60	3.55	VG
Application	24	20	8	8	60	3.00	G
Reflection	22	18	10	10	60	2.87	G
<b>Mean</b>						3.27	G

Note: VG=very good, G=Good, QG=Quite Good, NG=Not So Good

Table 2 describes assessment results of student worksheet II. Of the 60 students who followed the advanced test, their average score is 3.43, with the following details: In terms of developing ideas, 45 students get a score of 4; 10 students get a score of 3; and 5 students are with a score of 2. Their overall average score are 3.67 (very good category). For structuring ideas, 36 students get a score of 4; 21 students are with a score of 3; and 3 students are with a score of 2, with a mean score

of 3.55 (very good category). The mean score for application is 3.34 (good category) with the following details; 28 students are with score 4; 24 students are with score 3; and 8 students are with score 2. The average score for reflection is 3.17 (good category), with the following details: 28 students are with score 4; 18 students are with score 3; 10 students are with score 2; and 4 students are with score 1.

**Table 2.** The Result of LKPD II, Theme 'The Causes and Effects of Global

Constructivism Stages	Score				N (Students)	Mean	Category
	4	3	2	1			
Developing ideas	45	10	5	-	60	3.67	VG
Structuring ideas	36	21	3	-	60	3.55	VG
Application	28	24	8	-	60	3.34	G
Reflection	28	18	10	4	60	3.17	G
<b>Mean</b>						3.43	G

Note : VG=very good, G=Good, QG=Quite Good, NG=Not So Good

The stage of 'structuring ideas' gained mean score of 3.55 (very good) in which students are able to differentiate the types of ecosystems, to explain the characteristics of peatland ecosystems, and mentioning the biotic and abiotic components in the water ecosystems (student worksheet 1). In student worksheet 2, students are able to explain the process of climate change and its impacts to the environment.

In the application stage, student worksheet 1 shows mean score 3.0 and student worksheet 2 shows 3.34 within the criteria 'good'. Questions in the worksheets related to this stage require the students to apply the ideas that they have developed to solve a problem, for instance: why land and forest fire could happen and why the fire is hard to cease (student worksheet 1), and what the correlation between global warming

and atmosphere layers (student worksheet 2). In the last stage (reflection), student worksheet 1 shows mean score of 2.87 and student worksheet 2 shows 3.17 within the category of 'good'. From the result of the advanced test from both student worksheet, it can be seen that the highest score from the constructivism stages is on the developing ideas and structuring ideas. Meanwhile, the lowest score is on the reflection stage.

### Verification test

To test the truth of competence process in each stage of constructivism learning namely: developing ideas, structuring ideas, application, and reflection, the researcher compared the results from post hoc test to the experiment II from the previous study (Fitri, 2016). The comparison result on the stages of development from both student worksheets is presented in Figure 2.

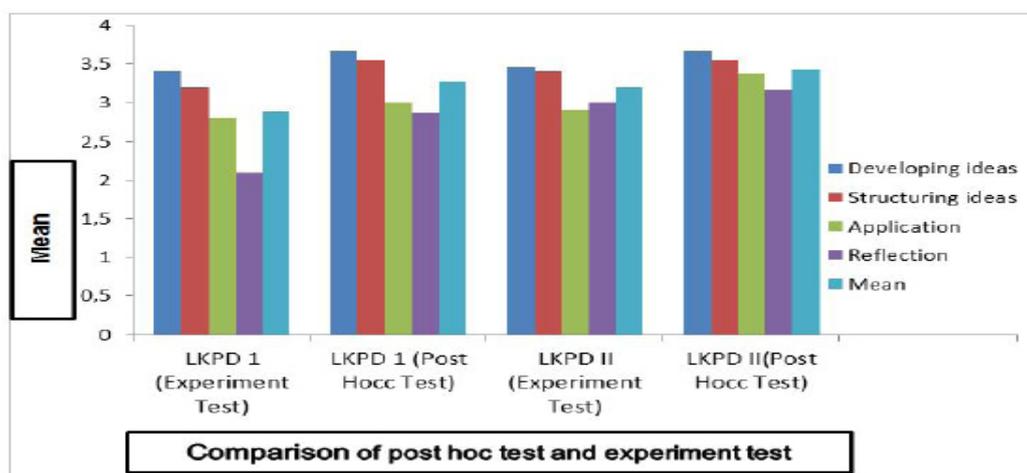


Figure 2. The Comparison of Advanced Test with The Experimental Test II on the Stages of Constructivism on Student Worksheet 1 and Student Worksheet 2

From the post hoc and experiment test II on both student worksheets (Fitri, 2016), it can be seen that the highest mean score is on the stages of developing ideas and structuring ideas. In experiment test II, the lowest mean score is on application stage, while on the post hoc test the lowest score is on reflection stage. The experiment test II shows mean score in student worksheet 1 which tends to be lower than student worksheet 2. Meanwhile, the post hoc test shows higher score than the experiment II test. Despite this slight difference, it can be concluded that students' competence in constructivism learning is on the category of 'good'.

## DISCUSSION

In the stage of developing ideas, students are able to express their pre-existing knowledge on the types of ecosystems and the issues of global warming and the impacts. Similarly, on the stage of structuring ideas, students are required to recall their memories to express what they already know. The themes in student worksheet 1 and student worksheet 2 are on issues of land and forest fires related to peatland ecosystems (Rasyid, 2014) which students experience in their daily life. The difference in students' competence is determined not only by teaching instruction, but

also students' engagement in the learning process. According to Cirik & Kaya (2015), teaching experience is not one of the most effective variables for designing and implementing constructivist learning environments. The implementation of a constructivist approach is not only related to teacher action, but also student participation in this process should also be taken into account.

In the stage of structuring ideas, students build their own assumptions to make useful knowledge in new situations. Students should make any efforts to understand the information they receive. They should be able to manipulate, discover, and create knowledge to fit their belief system. Questions in the worksheets at this stage provide an opportunity for students to develop ideas, and to select which ideas must be retained and which ones to be removed/replaced. This is in line with the conclusion by Bhattacharjee (2015) that new learning experience is built on prior knowledge in order to understand information, to make connections between old knowledge and new information. Students should compare, ask, challenge, investigate, accept or discard old information and beliefs for the new ones.

Later on, Sundawan (2016) argues that the learning process (knowledge acquisition) begins with the occurrence of cognitive conflict. This cognitive conflict can only be anticipated by self-

regulation, and the outcome of the learning process will be constructed by the students themselves through experience of interaction with their environment. The emphasis on teaching and learning focuses more on the students organizing their experiences, rather than on students' precision in replicating what the teachers say or do.

Saputra et al. (2016) states that the implementation of constructivism learning presented in some stages will be able to improve students' ability of quantitative literacy and scientific attitude. Student positive responses to the stages of constructivism learning help them build concepts and structuring ideas during direct interaction with groups or individuals.

Riau province has peatland ecosystems with the prolonging problems on land and forest fire for the past 17 years. This phenomenon is naturally experienced by the student participants in this study. By connecting students' experience to teaching and learning activities through student worksheets, it is expected to increase their learning motivation. This is because contextual learning can improve students' motivation thus facilitate their understanding on the materials (Yustina & Febrita, 2013). The constructivism approach has some main aims to help the students learn 'how to learn' by promoting critical thinking and independent learning (Kalpana, 2014).

In the application stage, mean score in post hoc test tends to be lower than the experiment 2 test. Questions on worksheets regarding this stage require the students to apply the ideas that they have developed to solve problems. However, some students seem difficult to relate some concepts, such as: which characteristics of peatlands can cause fire and how this fire impacts the climate change and other human activities.

The difference on the result between the post hoc and experiment test II is allegedly caused by the difference of participant numbers, where participants in the experiments II consist only 18 student participants selected randomly from one class. Meanwhile, the participants on post hoc test consist of 65 student participants. The bigger is the sample size approaching the population size, the error margin in generalization is smaller. Similarly, the smaller number of sample in comparison to the population size, the error margin in generalization is bigger (Darmadi, 2014).

The reflection stage in the post hoc gained the lowest score of the other stages. The reflection stage can be seen in the conclusions made by the students, according to Maimunah (2001) this stage aims to make students aware of changes of earlier idea and to familiarize them-

selves with the learning process that allows them to reflect on the extent to which their ideas have changed. This is related to the student's ability to process the information and to connect, integrate, incorporate, interpret, and analyze the results either by inductive or deductive principles.

According to Subahan & Ismail (2017) the skills of information processing relate to the students' ability to assess, organize, absorb, and use information effectively from various sources through the process of analyzing, interpreting, assessing and synthesizing. This is in line with the constructivism view which emphasizes the students' active role in developing their understanding and processing the information. Constructivist teaching is thus a learner centered approach in which students are actively involved in the construction of knowledge rather than passively engaged as passive listeners (Kalpana, 2014).

The overall result on the assessment of the constructivism approach stages could be classified as 'good'. This indicates that the developed student worksheet is in accordance with the desired constructivism approach and is able to help the students reconstruct their ideas related to the materials at the student worksheet.

The use of constructivism approach in education has an immediate effect on student learning. Students are active agents in the process of knowledge construction and dissemination. They participate in the learning process and are responsible for their own learning by making meaning in their own context (Hussain, 2012). The stages of constructivism approach help students build their knowledge both independently and collectively thus they can improve student learning outcomes (Sutisna, 2013). This idea was supported by Irawati (2011) who argues that constructivism learning invites positive responses from the students as they are fully involved in the process of constructing knowledge, practicing their communication skills in discussion and cooperation, and improving their responsibility by the individual or group works.

According to Amin (2012), the success and effectiveness of constructivism learning are much determined by the teacher efficacy in managing the classroom and learning activities within ideal achievement time, improving students' involvement and positive response, as well as improving the student outcomes. Constructivism-based cooperative learning application by using animated video, for instance, can inspire students and help them relate the teaching materials to the real-life situations around them (Imamah, 2012).

Constructivism emphasizes student-centered learning, learning styles and collaborative learning supported by teachers' scaffolding and authentic tasks (Dagar & Yadav, 2016). Constructivist learning can be developed using the principles of social constructivism to improve academic achievement, higher-order thinking and social and emotional skills of students. To implement the constructivist principle in teaching and learning process, teachers need to have strong knowledge of content as well as the knowledge of pedagogy. Constructivist theory is very useful for teachers in their efforts to help students understand the substantive and syntactic components of the subject being taught (Amarin & Ghishan, 2013).

Bada & Olusegun (2015) suggests that in constructivism approach, students need to actively build knowledge in their own minds by selecting and modifying information, verifying new information to the old information, and revising the information when it is no longer valid. This constructivism view considers the students as an active agent in the process of acquiring knowledge. Two important notions revolve around the process of constructing knowledge. The first notion suggests that learners build a new understanding by using what they already know. The second notion suggests that learning is active rather than passive.

### CONCLUSION

This study concludes that students' competence in constructing ideas through constructivism approach is 'good' at student worksheet 1 (mean score=3.27) and 'very good' at student worksheet 2 (mean score=3.43). The data also showed that there was a consistency with the second trial test.

The research implies that both worksheets (student worksheet 1 and 2) can improve students' competence in building their knowledge on the prevention of land and forest fire. It also implies that student worksheet 1 and 2 are eligible as reference materials for the teaching science education, especially for Basic Competence 3.8 on ecosystem, Basic Competence 3.9 on environmental pollution and Basic Competence 3.10 on global warming. These worksheets are suitable for Grade VII science teachers working at peat ecosystem in improving the students' understanding and knowledge on the prevention of land and forest fire as well as on the preservation of peat swamp ecosystem.

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## DIFFERENTIATION OF TEST ITEMS BETWEEN THE HIGH SCHOOL BIOLOGY OLIMPIAD IN NORTH KAYONG AND THE NATIONAL SCIENCE OLIMPIAD

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### ABSTRACT

The purpose of this research is to find out the differentiation between high school biology olympiad in the District of North Kayong and the National Biology Olympiad. The analysis is used to provide feedback to students regarding their knowledge in the forms of factual, conceptual, procedural, and metacognitive traits. This research is a descriptive study consisting of two phases: the stage of designing test items carried out by four Biology teachers who joined the group, Science Teachers Council, and the test tryout phase given to 33 high school students of class XI. This research resulted in the dimensions of knowledge which indicates that there are 79% (63 items) being in the dimension of the factual, as much as 15% (12 items) in the conceptual, as much as 6% (5 items) in the procedural, while the metacognitive dimension is 0%. The question package which was given in the preliminary phase test was 5% considered difficult, while in the final stage such difficulty was not found (0%). Therefore, it is concluded that the question items need to be revised because they have differentiation between high school biology olympiad in the District of North Kayong and the National Biology Olympiad.

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**Keywords:** knowledge dimension; bloom's taxonomy; difficulty index

### INTRODUCTION

The National Science Olympiad (NSO) is a science competition for students in elementary, junior and senior high schools, held by the Ministry of Education and Culture. This activity started in 2002. The NSO has become a medium for selecting Indonesian students with interests and competencies in science at the national level, who then can advance to the international level. Based on the results of interviews with the head of the Subject Teachers Council, in the implementation of coaching/guidance of candidates for high school biology olympiad held in schools spread in North Kayong District, 50% of the test items used comes from the previous years. The other 50% comes from a collection of the items

made by teachers who usually took them from the test questions of the school exam. This issue has not highlighted the distinctive traits of thinking for high school students. In fact, according to Khasanah et al. (2017), biology science requires distinctive traits of thinking. The problems are usually related to the uneven distribution of the material and also the unavailability of the key answers and the way to answer the questions

The test items made by science teachers in Indonesia still need a lot of improvement. This is evident from the unpreparedness of Indonesian students to compete globally. In addition, in various international standardized tests which have been taken by learners from Indonesia, the results are not satisfactory. Implementation of the 2013 curriculum is an attempt by Indonesia to catch up with other countries in the field of education, especially science (Pratiwi et al., 2016).

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The science lessons in the 2013 curriculum are conducted in an integrated way to provide opportunities for students to develop thinking skills, procedural skills, and scientific attitudes (Rosana et al., 2017). The preparation of test items for the Olympiad are undertaken to identify teachers' ability to prepare test items in accordance with the 2013 curriculum and revised Bloom's taxonomy. The teacher is a decisive component in the success of the teaching and learning process. According to Barinto (2012) teachers are the spearheads that directly relate to learners as subjects and objects of instruction. The competencies that must be possessed by a teacher include pedagogic competency, such as skills in preparing test items that match the dimension of knowledge and pay attention to the level in revised Bloom's taxonomy. In addition, teachers should also have skills in doing instructional evaluation. Instructional evaluation is a step to determine the characteristics of student achievement (Sasongko, 2016). One of the ways is with the activity of item analysis. This activity aims to measure whether or not the items that have been made and used belong to the good category.

The results of the item analysis can be used to revise the material to be measured and provide information to learners about the limits of knowledge they have. According to Anderson et al. (2001), the dimension of knowledge consists of four types: (1) factual knowledge; (2) conceptual knowledge; (3) procedural knowledge; and (4) metacognitive knowledge.

Factual knowledge covers the basic things that learners must know. Conceptual knowledge includes both explicit and implicit theories in different cognitive psychology. Procedural knowledge ranges from doing routine exercises to solving a new problem. Metacognitive ability helps learners to understand the material and solve problems encountered. Learners who use metacognitive strategies appropriately can be critical thinkers, problem solvers, and good decision makers rather than learners who do not use metacognitive strategies. Metacognitive thinking strategies are rarely applied in instruction (Septiyana et al., 2013).

Metacognitive thinking strategies can be applied by providing biology questions that require them to think critically. Critical thinking is an important skill to develop (Cahyarini et al., 2016). The test items that are capable of requiring students to think critically are the ones made by the National Science Olympiad (NSO) because NSO test items apply Higher Order Thinking (HOT). According Widodo & Kadarwati (2013), the app-

lication of HOT is capable of increasing interaction between students, and between students and teachers. Students will be more motivated to ask questions, express ideas and dare to solve a difficult question and use it in the national exam and or the National Science Olympiad (NSO) test.

National Science Olympiad (NSO) in the subject of biology at the district level is conducted annually. The test items are at the level of C4 (analyzing), C5 (evaluating), and the highest being C6 (creating). However, from results of pre-research conducted in one high school in North Kayong (February 2016), it was found that the items used in the early selection stage still used the cognitive domain at the lowest level of C1 which means at the remember level and C2 at understand level. Therefore, a study was conducted to identify the differentiation between the test items used in the preliminary selection process at the district level, especially in Kayong Utara District and the NSO test items. The differentiation was examined from 2 dimensions, i.e. the dimensions of knowledge and the item difficulty index.

## METHODS

This research is a descriptive study. It consists of two phases namely the phase of preparing the items and the test phase. The item preparation phase was carried out in North Kayong by six biology teachers who joined the Science Teachers Council in North Kayong. The data obtained from this phase 1 research were test items from Biology Olympiad of high school level in the form of multiple choice as many as 2 packages (Package 1 and Package 2), each package having 40 items. Package 1 was intended for use in the preliminary round and package 2 for the final round. Both packages were then processed descriptively and qualitatively by other Science Teachers Council participants (11 people) in order to map the items according to the revised Bloom's taxonomy.

The mapping aims to measure if the items are in the factual, conceptual, procedural, or metacognitive dimension. In addition, the calculation of the distribution was also done to determine the cognitive domain which ranges from remember (C1) to create (C6). Both packages of test items were validated by 2 lecturers of Biology Education at the Faculty of Teacher Training and Education (FKIP) Tanjungpura University. The type of validity used was content validity. This validity is chosen because this type of validity is often used in the assessment of learning outcomes.

In phase 2 the items were tried out on 33 students in Sungai Raya in the odd semester of the academic year of 2016/2017. The test tryout was conducted for 2 meetings in the same week. The first meeting was for items of the challenge round and the second meeting for items of the final round. Then, the calculation of reliability and item difficulty index were performed.

The multiple choice item reliability was calculated with Kuder Richardson (KR-20) using the following formula:

$$KR-20 = \frac{k}{k-1} \left[ 1 - \frac{\sum p(1-p)}{(SD)^2} \right]$$

where:

k : number of items  
(SD)<sup>2</sup> : variant

The difficulty index was calculated using the following formula.

$$P = \frac{B}{JS}$$

where:

P : Difficulty level  
B : Number of test takers who answer questions correctly  
JS : Total number of test takers

According to Arifin (2009) difficulty index is classified as follows:

P: 0.00 - 0.30 categorized as difficult  
P: 0.30 - 0.70 categorized as medium  
P: 0.70 - 1.00 categorized as easy

A number used to determine the level of difficulty of a test item is called a difficulty index. The difficulty index is in the range of 0.00 to 1.00. The difficulty index is also known as Proportion (P). If P 0.00, the item is very difficult; if P = 1.0, then the item is too easy (Syamsudin, 2012).

## RESULTS AND DISCUSSION

The selection of outstanding learners in the field of biology is carried out at the beginning of each semester every year. This activity is the agenda of the Education Office as a step to improve the quality of education in the district. So one of the objectives of the NSO in the field of biology is to select outstanding students in the

field of mathematics, science, and technology.

The selection is conducted in different levels starting from school to the district/city, provincial, national, and international level. The selection chart is shown in Figure 1 below. Based on Figure 1, school-level selection is the gateway for each learner to move on to the next stage. Each test item should have its level of difficulty measured and its knowledge dimensions reviewed.



Figure 1. NSO Stages

The theoretical characteristics of Biology Olympiad should only from the theory learned in high school or equivalent. However, to be able to answer the questions with good analysis, learners need insight, accuracy, and way of thinking. Thinking is all mental activity that helps formulate or solve problems to make a decision, understand, and seek answers (Husamah, 2015). This can be obtained from guidance and coaching with good quality questions. Activity in the form of coaching and mentoring of NSO is obviously needed by learners. Some learners complain about the lack of knowledge, understanding and solving NSO test items in Biology.

The number of test items successfully prepared by 4 Biology teachers who are members of the Science Teachers Council of North Kayong District amounted to 80 items in the form of multiple choice questions. The study on the quality of the items from the aspects of knowledge is shown in Figure 2 below.

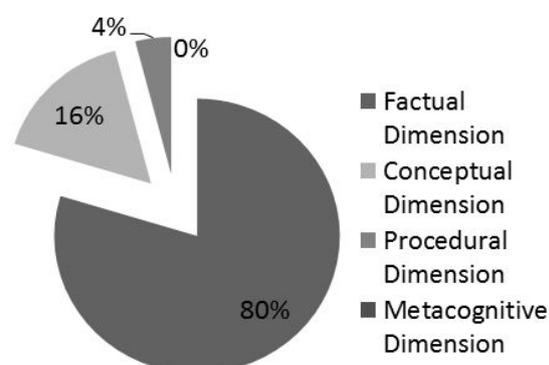


Figure 2. Distribution of Knowledge Dimension

Figure 2 shows that there are 63 items (80%) are in the factual dimension, 13 items (16%) on the conceptual dimension and 4 items (4%) on procedural dimension. While the meta-cognitive dimension is not found (0%). Based on the results of item compatibility analysis with the biology materials, 100% of the questions are in accordance with the material content outline tested in the selection of biology olympiad. Any types of test items that are prepared be it for daily test, school exam, and national exam, must be made based on the content outline and developed in accordance with the indicator of the item.

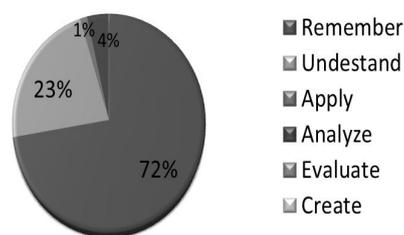
The problem is that the indicator of the Olympiad test items downloaded from the internet does not display the contents in detail. If the content outline of the Olympiad material does not appear in in test item, it will lower the ability of the item to measure what it should from the test results. Thus it was decided by the teachers who prepared for the Olympiad test items to reformulate the indicators of the items. According Maiza (2013) a test item is good if it has been in accordance with the content outline that has been formulated. If the item is not in accordance with the formulated outline, then it cannot function properly.

Based on Bloom's revised study of the distribution of taxonomy in the cognitive domain, it is found that most (50%) of questions are in C1 and C2 levels. Based on the results of the analysis of the items, it was found that a question can be easily answered if the student can remember the material in the textbook. In line with that, Rusyati & Rustaman (2013) argued that to answer a question, first most students have to read, understand and memorize the material in it. This is because the question is the as that found in the textbook, so they only need to remember what they have read from the textbook or from listening to the teacher's explanations.

In addition, the selection of questions in levels C1 and C2 is due to several other reasons as follows: (A) Teachers do not have enough time to think of or prepare items that demand learners' high-level of thinking; (B) Lack of access to references, and limited internet access both at work and in residential areas; and (C) Adjusting to the conditions of learners in the school.

In general, the results of the study of the distribution of test items in the cognitive domain are shown in Figure 3. Figure 3 shows that the items made by biology teachers still focus on the learner's memorization and comprehension. This is in line with Ningsih's (2016) study which stated that there has not been an item made by teachers

to measure the aspects of evaluate (C5) and create (C6).



**Figure 3.** Distribution of Items Based on Levels of Bloom's Taxonomy on The Cognitive Domain

Creativity in preparing test items still needs to be improved. The interview with the head of the Science Teachers Council of North Kayong District shows that based on experience during teaching, Biology questions that appear in the school exam is on the dimensions of factual and conceptual so that teachers feel that they have the obligation to familiarize the students with the material by giving questions to be memorized, consequently learners are not accustomed to thinking critically in answering questions.

Since most of the questions prepared in the cognitive domain of C1 and C2 levels, it will cause learners to be less capable of making new things or solving a problem. Problem solving is a model that can be used to improve learning outcomes (Triyuni, 2016). But the percentage of test items in the form of problem solving is lower than the items that need memorizing. The reason why teachers prepre more items that require memorizing in the cognitive domain levels C1 and C2 is related to educational goals today. There are two important educational goals i.e., to develop memory and to encourage transfer process. The occurrence of the transfer process is a sign of the success of a learning process. Memory or retention is the ability of a learner to recall learning materials for some time after teaching with the same accuracy as when the learners are following the lesson. Transferability is the ability of a learner to use what he has learned to solve new problems, to answer new questions, or to facilitate the learning of new things (Mayner, 1996). In short, the ability of memory is defined as the ability of a student to remember what he has learnt, while the transfer ability requires a learner to be able to remember and also understand and use what he has learned (Bransford et al., 1999).

Teacher's references in preparing Olympiad test items is also a standard of the quality of the items made in addition to the NSO syllab-

bus. The items to be prepared should refer to the instructional syllabus and should at least be adjusted to the learning objectives contained in the valid or standard lesson plans. But in the process of preparing a test item, most teachers rely solely on the textbook. It means that teachers use the learning syllabus only in designing lesson plans as a complementary teacher administration to be applied in classroom instruction. Teachers hardly ever use the syllabus and lesson plans as one of the main sources in preparing the Olympiad test items. The correlation between knowledge dimension and aspects of Bloom's taxonomy is shown in Figure 4.

Based on the correlation between knowledge dimension and Bloom's taxonomy, the results of this study show the correlation from the distribution of the NSO test items. In Table 1 illustrates of distribution test items based on revised Bloom's taxonomy and knowledge dimension.

**Table 1.** Distribution Test Items Based on Revised Bloom's Taxonomy and Knowledge Dimension

Revised Bloom's Taxonomy	Knowledge Dimension			
	A	B	C	D
1	58	0	0	0
2	5	13	0	0
3	0	0	1	0
4	0	0	3	0
5	0	0	0	0
6	0	0	0	0
Total	63	13	4	0

Knowledge Dimension:

A = Factual

B = Conceptual



**Figure 4.** Combination between Knowledge Dimension and Bloom's Taxonomy

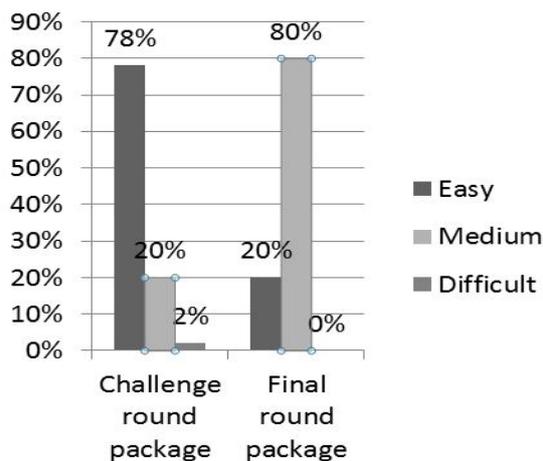
C = Procedural  
D = Metacognitive

Bloom Taxonomy Revision:

- 1 = Remember
- 2 = Understand
- 3 = Apply
- 4 = Analyze
- 5 = Evaluate
- 6 = Create

The distribution of test items prepared by teachers based on knowledge dimension and revised Bloom's taxonomy shows that most of the items are still at the level of remember and understand. The next items were tried out and the level of reliability calculated. The calculation of reliability aims to identify the level of accuracy and reliability of test scores. The calculation results have a range from 0 to 1. If the result is closer to the number 1, the reliability level of the item is higher. Based on the calculation of the data, the reliability score is R = 0.68. Based on the reliability criteria, the score of 0.68 belongs to the category of fair. This shows that the Olympiad test items prepared by teachers are quite reliable.

The items that have been examined from the knowledge dimension were then tried out to determine the reliability and the level of difficulty. In the try-out process, it was done 2 times with 2 days of lag time in the same week with different test packages. The results of the tryout analysis of the Biology olympiad test items can be seen in Figure 5.



**Figure 5.** Result of Analysis on Test Items Difficulty Level of Challenge Round Package and Final Round Package

The percentage of the prepared items should have a balance between easy, medium, and difficult. However, the results obtained from Figure 5 indicate the absence of balance of difficulty because in the challenge package, the most dominant are items with an easy category (78%) while the final package belongs to a medium category (80%). But in both packages, the percentage of difficult questions is very low (2% and 0% respectively). Test items with the results of difficulty analysis as shown in Figure 5 are not recommended for use in the Olympiad. This is in accordance with the opinion of Anastasia (2003) who stated that if the purpose of preparing test items is for a selection process, then it should have a medium or difficult level of difficulty. Items in the easy category should not be used. But should it be used, a few would be enough.

The item difficulty index of the data in Figure 5 reflects the low level of learners' experience to interact or work on a test item based on Higher Order Thinking Skill (HOTS). This type of HOTS items appears in the national exam and Trends in International Mathematics and Science Study (TIMSS). Based on the test tryout results, only 3 students who can correctly answer the questions in the difficult criteria. The results of interviews with 11 students who answered the items incorrectly show that the materials in the test items have not been learned before.

To this point, the test items they have done are those whose answer choices are definite and do not require analysis or high-level thinking processes. Being used to answering test items of memory and understanding alone has caused them to learn by memorizing in the absence of synthesis or analysis of the material learned. It will

obvious if the question is in the form of essay, where learners will have difficulty in giving an explanation of the material examined.

The findings of this research are significant for teachers and test developers. They must have the competence in analyzing the test material so that they can prepare the items up to the level of evaluate and create especially for the Olympiad test. This is because the Olympiad test items aim to select outstanding learners in the field of biology so it requires questions with higher difficulty level (Nurinda, 2014). Thus the Olympiad test items that have passed the phase of item analysis can be used as a basis in making the right decision. According to Boopathiraj & Chellamani (2013) to date, item analysis is an important phase in the development of tests or instruments. So it is expected that teachers and instrument developers can apply it in the final process of instrument preparation. For example in preparing Olympiad test items and the items that serve as a test of learning outcomes.

## CONCLUSION

There are 63 items (80%) in the factual dimension, 13 items (16%) in the conceptual dimension, and 4 items (4%) in the procedural dimension, while the metacognitive dimension is not found (0%). Among the 80 items prepared, 72% of them is at the remember level (C1) and 23% at the understand level (C2), only 1% at the apply level (C3), 4% at the analyze level (C4), while evaluate (C5) and create (C6) are not found (0%).

The compatibility of the olympiad test items prepared by the teachers with the indicators set in the olympiad content outline is 100%. The reliability of NSO items is the fair criterion ( $R = 0.68$ ). The item difficulty index shows that the most dominant items prepared in the challenge package belong to the easy category (78%). In the final package, the most dominant belongs to the medium category (80%). In both NSO packages, the lowest category is the difficult category (2% and 0%).

Therefore, it can be concluded that there is a differentiation between the test items used in the preliminary selection for the Olympiad in North Kayong and the items used in NSO (National Science Olympiad). There is a need for training on the preparation of items at the levels of C4, C5, and C6 in accordance with NSO test items so that it will improve student achievement in North Kayong District.

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## THE DEVELOPMENT OF RESEARCH-BASED LEARNING MODEL WITH SCIENCE, ENVIRONMENT, TECHNOLOGY, AND SOCIETY APPROACHES TO IMPROVE CRITICAL THINKING OF STUDENTS

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### ABSTRACT

Learning physics in SMAN 1 Bukittinggi was conducted through theories and practicum that verified the theories. The preliminary survey on the implementation of physics learning showed that teachers had not yet applied research-based learning. There were still many students who had not yet mastered the learning of physics. Supporting facilities such as physics laboratory and the equipment had been available, but they are not yet optimally utilized. Research-based learning model is one of learning models that can improve critical thinking skill and students' learning outcome. The research is aimed at developing research-based physics learning model with Science, Environment, Technology, and Society (SETS) approaches which was valid, practical, and effective to improve students' critical thinking. This research used a 4D model from Thiagarajan. The instruments of the research were interview guidance, observation sheets, validation sheet of the learning model and the instructional materials, questionnaire response of teachers and students, critical thinking skill test, and assessment sheet of skills and attitudes. The result of the research showed that the developed learning model and the instructional materials belonged to the category of valid which was in accordance with the expert judgment. The learning model and the instructional materials belonged to the category of practical based on the result of the observation, and the response of teachers and students. The implementation of Research-based Physics Learning with SETS approach was effective in improving critical thinking skills and learning outcomes of the students.

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**Keywords:** research-based; SETS; critical thinking

### INTRODUCTION

Science and technology currently grow very rapidly. Students are required to master science and technology, so that they are able to assess the impact and benefits of technological development on natural and social environment in the community. Efforts to improve the quality of students cannot be separated from the educational process. Educational policy change made by the government is one form of efforts to improve the quality of education in Indonesia. One of such efforts was the change of Education Unit

Level Curriculum into the 2013 Curriculum. The implementation of the 2013 Curriculum is followed by the provision of student books and teacher books which were given freely. In addition, socialization was also done to teachers about the implementation of this curriculum in learning.

The 2013 Curriculum embraces the idea that science cannot be transferred from teacher to student. Students are subjects who have the ability to actively seek, process, construct, and use knowledge. Students should be given the opportunity to construct knowledge in the learning process. The 2013 Curriculum emphasizes on the competence of graduates who have characters, and have skills and knowledge integrated in the learning materials. Learning using the 2013

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Curriculum based on scientific activities can be done with a scientific approach. This approach involves observing, asking, trying, reasoning, and communicating.

Physics is one of the subjects that examine natural phenomena using scientific methods. The subject of physics is not only about mastering the knowledge in the form of facts, concepts, or principles, but also an experience in the process of discovery using the skill of scientific process. Physics learning should be carried out with a scientific approach. The materials of physics are expected to increase the knowledge and admiration of students to the greatness of God. Therefore, the subject of physics can be mastered by the students, the teacher must use learning model and the instructional materials in accordance with the 2013 Curriculum.

The results of the preliminary survey at SMAN 1 Bukittinggi showed the instructional materials used by teachers had not shown any learning steps with a scientific approach yet. In addition, the teaching materials used by teachers had not yet varied. Teachers had implemented the learning model in accordance with the 2013 Curriculum. There had not been many teachers (34%) who had used information technology to make learning more interesting. The activities of students in learning still lacked, and students tended to be passive. The motivation of students in learning was also low because there was no variation that teachers used in learning. Students were less able in solving physics problems because they were less critical in finding problem solutions, and they still lacked in mastering the physics concepts. These can be seen from the questionnaire results of the Critical Thinking Skill of the students in physics subjects by using the California Critical Thinking Skill Test.

From the analysis, it was found out that the average of the students' critical thinking skill was 65.2% which meant that the critical thinking skill of the students was still lower than the expected ideal condition, so that it needed to be improved. From the analysis of the indicators of critical thinking skill, 69.5% of the students had the ability to analyze, 64% had the ability to evaluate, 64.1% to make inference, 69% in deduction, and 59% in induction in learning. One of the causes of low critical thinking skills of students was the application of learning models that had not grown motivation, interest, and critical thinking skills of students. One of the causes of the students' low critical thinking skills was the application of learning models that had not improve

motivation, interest, and critical thinking skills of students. The students' low critical thinking skill influenced their learning outcomes. The daily test results of grade X students of SMAN 1 Bukittinggi were categorized as fair. The average classical of students mastery learning was 63.7%.

The lack of students' ability in mastering the concept of physics was because they were not equipped with necessary skills to master it such as problem-solving skills, science process skills, critical thinking skills and reasoning skills. The lack of briefing of these abilities could be seen from the learning process of Physics which mostly used lecturing method which was explanations of theories, elaborations of formulas with the help of mathematics, and solving physics problems. Many teachers admit that the use of lecturing method in physics learning fails to instill the mastery of physics concept (Hake, 1998; McDermott, 2009; Redish, 2003). As a result, students did not have the necessary skills to solve problems and were unable to apply the material they had learned.

In accordance with the problem analysis, one solution to overcome the problem was to foster the motivation of students in the learning of physics, so that learning became more meaningful for them. Meaningful learning can improve the students' knowledge as a whole. Students' motivation can be increased by applying a learning model that involves students actively. Therefore, a model of physics learning that could improve critical thinking skills of students was developed. The learning model should be integrated with the appropriate approach so as to improve the students' critical thinking skills. The appropriate learning model for this problem was the research-based learning model with the approach of science, environment, technology and society (SETS). The research-based learning with SETS approach was expected to help students solve problems and encourage students in improving high-level thinking skills, one of which is critical thinking skill.

Research-based learning is a student centered learning model that integrates research into the learning process. The learning process is the implementation of the combination of research and meaningful learning. Research-based learning is multifaceted, referring to various learning methods, so that all students' learning outcomes come from a simple research that they do, for example through experiments and field studies (Wardoyo, 2013; Griffith, 2008; Jyrhämä, 2008; Kynäslahti, 2006). Research-based learning provides opportunities for students to formulate

problems, review theories, construct hypotheses, collect data, analyze data, and conclude the results obtained.

Poonpan (2005) states that "Research-based learning is an effective way to change students' learning and to practice about how to learn by doing. Research-based learning is a system of instruction which uses an authentic learning, problem solving, cooperative learning, hands-on, and inquiry discovery approach, guided by a constructivist philosophy". Prahmana (2015) defines research-based learning as a model of learning which is authentic, problem solving, cooperative, contextual (hands on and minds on), and inquiry discovery approach based on a constructivist philosophy, so that students can improve their learning independence, critical thinking skills, creativity and communication skills. Research is an activity to discover, develop and test the truth of knowledge and summarize the findings obtained (Wardoyo, 2013).

The competencies acquired by students after research-based learning are: (a) to have an understanding of the concepts of physics and research methods; (b) to be able to solve problems creatively, logically and systematically; and (c) to have a scientific attitude that always seeks truth, and be open and honest (Arifin, 2010). The results of relevant research that has been done shows that the application of research-based learning that is life skill-oriented can increase the activity and the mastery of the essential concepts of university students in thermodynamics. The use of research-based student worksheets in physics learning is effective in improving the competence of students (Usmeldi, 2015a). Research-based learning with a scientific approach to effectively improve science process skills of students (Usmeldi, 2016a).

The SETS approach is an integration of science, environment, technology, and society (Maghfiroh, 2012). Learning with SETS approach is an integrated learning that is expected to teach students to have an integrative ability in four elements, namely: science, environment, technology, and society. The SETS approach can encourage students to study science in its entirety, take advantage of it in technology applications, know its impact on the environment, and know its impact on the development of society. According to Nuryanto (2010), SETS is a learning approach that links its four elements, namely science, environment, technology, and society in learning process. The subject matter is tied to concrete examples related to the community around the student, so that students can understand the ma-

terial easily. According to Minarti (2012) learning with the SETS approach can form students who have reasoning skills and comprehensive thought when they are faced with a problem. In learning with SETS approach, both the teacher and the students have a decisive role in the achievement of the learning objectives. The role of the teacher is to create a thinking pattern that sees the future with its implications, and take the students to always think critically in solving problems (Nuryanto, 2010; Nugraheni, 2013).

Critical thinking is one of the more complex forms of thinking activity which involves activities in analyzing more specific ideas, differentiating, choosing, identifying, assessing, and developing them in a more perfect direction. Critical thinking is a process and an ability to make rational decisions. Ennis (1996) proposes that the test to measure critical thinking skills is developed from five indicators, namely: (1) analysis, measuring the ability to understand the meaning of varied data, experience, and assessment; (2) Evaluation, measuring the ability to judge information and state the results of one's reasoning; (3) Inference, measuring the ability to identify the information needed to make conclusion; (4) Deductive reasoning, measuring one's ability which is started from general idea or a premise to a specific conclusion; (5) Inductive reasoning, measuring one's ability which is started from a premise or an application related to knowledge or an experience to a general conclusion.

Research-based physics learning with SETS approach is expected to be able to improve students' critical thinking skills, mastery of physics matter, and scientific attitude. In connection with that matter, the research problem was formulated as follows: (1) How did the process of developing research-based physics learning model with SETS approach improve critical thinking skills of students? and (2) How was the validity, practicality, and effectiveness of research-based physics learning model with SETS approach?

## METHODS

The research activities were carried out to obtain information about the user needs, while the development activities were carried out to produce research-based learning models with SETS approach. The research design used the 4D research and development method by Thiagarajan. According to Thiagarajan (Trianto, 2010), the stages of the 4D model are *define*, *design*, *develop*, and *disseminate*. The subject of the research was the physic learning model for high

school students. The respondents of the research were students and physics teachers of SMAN 1 Bukittinggi. The instruments of the research were interview guidance, observation sheets, learning model validation sheets, lesson plan, students' worksheets, teachers' and students' response questionnaire, critical thinking skill test, and assessment sheets of skills and attitudes.

Based on the type of data, the data were analyzed qualitatively and quantitatively. The data of learning model validation, lesson plan, students' worksheets, questionnaires, and assessment were analyzed descriptively, and compared to the criteria of validity, practicality, and effectiveness of learning model, lesson plan, and students' worksheets. The data of learning implementation were analyzed qualitatively by revising the legibility and the action steps in the student's worksheet. The revision was conducted in accordance with the observation results done by the observer to the learning implementation, and the opinions of experts and peers.

**RESULTS AND DISCUSSION**

**Research-based Physics Learning Model with SETS Approach**

Based on the preliminary survey results and the critical thinking skill analysis of the students, a research-based physics learning model was designed with SETS approach. The integration of the SETS approach in the research-based

learning process was done by adjusting the learning steps. Research-based learning is a learning model that integrates research procedures in the learning process. Research is an important tool to improve the quality of learning. The research component consists of background problems, problem formulation, literature studies, methods, research results and discussion.

Learning with the SETS approach is a learning that can educate students to have an integrated ability in science, environment, technology, and society. SETS approach can encourage students to learn science completely and make use of it in technology applications, and learn its impacts on environment and its influence on society development. There are six stages of research-based learning model with SETS approach namely: (1) identifying problems related with environment, technology, and society; (2) formulating the problem; (3) reviewing theory; (4) formulating hypothesis; (5) collecting and analyzing data; and (6) interpreting and concluding research result.

**Validity of Learning Model**

Research-based physics learning model with SETS approach was validated by four expert judgments. Aspects assessed by the expert judgment were the feasibility of the content, the construction, and the language. The validation of the learning model and the instructional materials (lesson plan, students' worksheet, and assessment) can be seen in Table 1.

**Table 1.** The Validation Result of Learning Model and the Instructional Materials

Validation Aspect	Expert Judgment				Average	Category
	HM	RM	IM	KR		
Learning model	83	82	73	83	80.3	Valid
Lesson plan	78	82	79	77	79	Valid
Students' worksheet	73	79	79	74	76.3	Valid
Assessment	78	80	84	82	81	Valid

The validation result of the learning model, lesson plan, student worksheet, and assessment indicated that the learning model and the instructional materials were categorized valid.

**Practicality of Learning Model**

The experiment of the learning model was done to obtain the practicality data of the model and the instructional materials. The experiment of research-based learning model with SETS approach was conducted in four meetings (face to face). The experiment of the learning model involved physics teachers of SMAN 1 Bukittinggi as observers. Observers were in charge to obser-

ve the implementation of students' learning and activities. The practicality of the learning model was reviewed from the learning implementation, and the response of the teachers and the students. The observation result of the learning implementation showed that the learning model could be implemented by the teachers and the students. The teachers' responses to the implementation of learning show that the learning models are a very practical category. The teachers' response on the lesson plan, the students' worksheet, and the assessment of research-based physics learning model with SETS approach was categorized practical (Table 2).

**Table 2.** Practicality Result Based on Teachers' Response

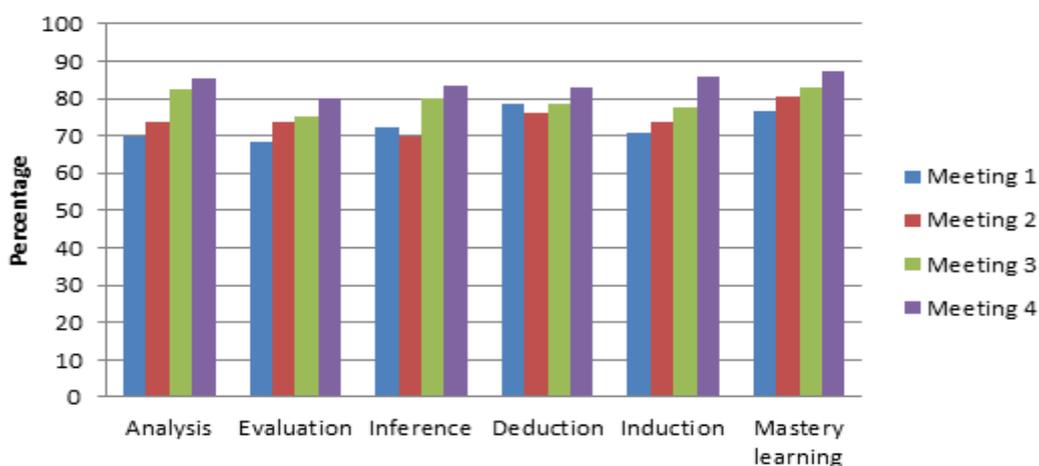
The Instructional Materials	Average (%)	Category
Learning model	89.97	Very practical
Lesson plan	80.3	Practical
Students' worksheet	78.9	Practical
Assessment	75.7	Practical

The most students (89.60%) stated that research-based physics learning with SETS approach was practically implemented. Thus, rese-

arch-based physics learning with SETS approach was practical to use to improve students' critical thinking skills.

### Effectiveness of Learning Model

The effectiveness of research-based physics learning model with SETS approach to improve students' critical thinking skills was reviewed from the students' competence in the areas of knowledge, skills and attitudes. The valuation of the students' knowledge was conducted by giving quiz at the end of each meeting. The valuation of the knowledge was focused on the aspect of the students critical thinking skill by using essay assessments. The average of students' critical thinking skills and mastery learning on each meeting can be seen on Figure 1.

**Figure 1.** The Average of Students' Critical Thinking Skills and Mastery Learning

The Figure 1 shows that students' Critical Thinking Skills showed that there was an increase on every meeting on indicators of analysis, evaluation, and induction. Indicators of inference and deduction decreased slightly in meetings 1 and 2. The average score of the students' critical thinking skills from the four meetings was 76.9. Percentage mastery learning of students increased at every meeting.

The students' learning outcomes are presented on Table 3. The average learning outcomes of students in the knowledge domain was

76.9 and the mastery learning percentage of the students was 87.5 on the fourth meeting. The average score of students' learning outcomes in the skill domain was 83.4, and the percentage of mastery learning was 90.6% on the fourth meeting. The average score of students' learning outcome in the attitude domain was 83.9.

The average score of students' learning outcomes in the knowledge domain include good categories, skills and attitudes include very good category. More than 85% students had fulfilled the score of defined mastery learning criteria.

**Table 3.** Students' Learning Outcome

Learning Outcome	Meeting (direct)				Average	Category
	1	2	3	4		
Knowledge	71.9	73.2	78.8	83.5	76.9	Good
Skill	77.2	82.4	84.4	89.7	83.4	Very good
Attitude	76.2	81.6	86.3	91.7	83.9	Very good

Thus, it can be stated that research-based physics learning with SETS approach was effective to improve students' critical thinking skills. The research-based physics learning model with SETS approach developed in this research was stated valid, practical, and effective in improving critical thinking skills of the students. The improvement of students' critical thinking skills is the impact of research-based learning with SETS approach. Redhana (2008) states that SETS approach is a unity in the learning process, so that students have high-level of thinking skills, which one of them is critical thinking skill. Yulistiana (2015) concluded that the use SETS approach could improve students' critical thinking skill and students' mastery of learning. Purwandari (2015) states that physics learning using SETS-based physics modules can improve students' critical thinking skills. Learning the inquiry model with SETS approach on the topic of solubility and solubility products can improve the critical thinking skills of students (Rahma, 2012).

Research-based learning can improve students' skills in solving problems, thinking critically, and finding knowledge (Srikoon, 2014; Alshehry, 2014). The research-based learning is effective in improving the mastery of physics concepts and students' generic abilities (Usmaldi, 2015b). Research-based learning can improve the science process skills in physics (Usmaldi, 2016a). Research-based physics learning with scientific approach is effective in improving students' science literacy (Usmaldi, 2016b). Research-based learning can increase students' curiosity about the subject matter (Lui, 2011; Walkington, 2011).

The inquiry methods used in research-based learning can improve cognitive skills, critical thinking skills, scientific work skills, and scientific attitudes of the students (Cahyani, 2014; Sulistijo, 2017; Hairida, 2016). According Trisnasih (2013) in his research that the application of research-based learning could increase the activity, the skill and the knowledge of students in science lessons. Irianti (2007) in her research concluded that the SETS approach was effective for teaching students in physics learning on camera and periscope material. SETS-based science learning can improve the learning outcomes, the process skills, and the activeness on every meeting (Yulistiana, 2015). Research-based learning model with SETS approach was implemented in the laboratory.

The importance of laboratory activities to understand the concepts of physics for students is proposed by Ivins and Raghubir. According to

Ivins (McComas, 2005) Laboratory activities are more effective in helping students learn physics than learning from discussions. Raghubir (McComas, 2005) found out that students showed high level of cognitive ability when they actually acquired knowledge through laboratory activities rather than using the laboratory to verify the theories that had been studied. The inquiry practicum activities are more challenging for students in finding the concept of physics than the verification activities. Cox & Junkin (2002) in their researches found out that the inquiry practicum activities could improve students' skills in conducting practicum. Deters (2005) and Weaver (2008) in their researches found out that the inquiry practicum activities could improve students' skills in thinking logically, solving problems, and give impressive experience of laboratory activity. Guided Inquiry-based practicum learning can improve the critical thinking skills of students (Wulandari, 2013).

Research-based physics learning with SETS approach can make students master physics competence completely, not only master the knowledge and the skills but also the care to the environment, technology, and society. The process of attitude habituation was assessed from the beginning when students perform an attitude indicator until it becomes a habit. The formation of attitude takes a long time, as stated by Nugroho (2011) that the formation of attitudes takes place in several stages to change personal attitude that starts from dissatisfaction, followed by having a logical and rational vision, having the courage to take risks and responsibility until the stage of consistent. In the consistent stage, it can be said that there is a change in the person's attitude. It is certainly not easy considering various challenges faced by students every day. Therefore, within a few meetings of learning, it was difficult to know the students' level of consistency.

Learning activities with SETS approach can improve students' problem-solving skills because the learning activities begin with the problem presentation. The students are required to solve problems that exist in their environment. In the final stage of learning, students are expected to be able to master the material of physics and solve problems. Prahmana (2015) defines research-based learning as a problem solving learning system with the point of view of problem formulation, problem solving, and communicating the benefits to foster learning independence, critical skills, creativity, and good communication skill.

## CONCLUSION

The research had resulted in research-based physics learning model with SETS approach. Research-based learning is a learning model that integrates research procedures in the learning process. Learning with SETS approach is a learning that is able to teach students to have an integrated ability in science, environment, technology, and society. SETS approach can encourage students to study science as a whole, use science into technology applications, and study its impact on the environment and society development. Stages of research-based learning model with SETS approach are: (1) identifying problems related with environment, technology, and society; (2) formulating the problem; (3) reviewing theories; (4) formulating hypothesis; (5) collecting and analyzing data; and (6) interpreting and concluding research result.

The developed learning model was valid, practical, and effective in increasing students' critical thinking skill. The average of students' critical thinking skill was good. More than 85% of students mastery learning on the knowledge and the skill competence. The skills and the attitudes of the students were very good.

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## DEVELOPING CHARACTERS BASED ON LOCAL WISDOM OF BALI IN TEACHING PHYSICS IN SENIOR HIGH SCHOOL

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### ABSTRACT

Human resources with good characters are badly needed in a national development. Hence, developing characters, especially the development of characters based on local wisdom is highly needed. This study was part of a study of local culture-based Physics model of teaching at senior high school, i.e., the need analysis and conceptual model prototype stage. The subjects were 20 physics teachers who had at least 10 years of teaching physics experience at public and private senior high schools in Singaraja, Bali. The study used questionnaire, observation guide, and interview as the instruments for collecting the data. The data were analyzed by a descriptive-qualitative analysis. The result showed that (1) Nine Balinese local wisdom-based characters could be developed in physics teaching; (2) The method that is appropriate for the local wisdom-based development of characters is inquiry from various perspectives, discussion, and demonstration; (3) The core procedure of teaching that can develop the students' character are exploration, focusing attention, inquiry from various perspectives (scientific, sociocultural, historical), elaboration, and confirmation.

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**Keywords:** physics teaching; local wisdom-based character; senior high school

### INTRODUCTION

Character building is very important and urgent (Samani & Hariyanto, 2012). We have to start from building characters, ethics, and good behaviors to develop the nation of Indonesia. This nation actually has a superior and noble civilization. However, this idea has received less attention in educational process, as evidenced from the behaviors such as blaspheming using vulgar expressions both in a demonstration or a social media, broadcasting false news (hoax), bullying, engaging in gang fightings, doing dishonest acts (cheating, corruption, plagiarism), intolerance toward differences and laziness which are done by

some people, children and the adults. This phenomenon could be taken to represent Indonesian characters. These phenomena indicate a failure in developing value education. The decadence of the students' morality which cause the bad characters is an indicator of the teachers' failure in integrating knowledge about values with positive actions (Lickona, 1999; Lopes et al., 2013; Abu et al., 2015; Aisah, 2014).

This statement is supported by Suastra (2010) who state that contemporary Science (Physics) teaching accommodates less local wisdom values that are full with virtues. Baker et al. (1995) states that of school Science teaching does not pay attention to the children's culture/local wisdoms, then, as the consequence, the students will "refuse" or only accept part of science

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concepts that they are learning. Local wisdom is defined as the truth that has become a tradition. Local genius which is also often called local wisdom can be understood as an effort of human beings who through their cognitions to act and behave toward an object, or an event that occurs in a particular space (Ridwan, 2007).

Wisdom, which etimologically means one's ability in using one's mind position oneself in relation to an event, object or a situation, while the word local shows the space of interaction the event or situation takes place. Thus, local wisdom is substantially a norm that is binding in a community whose truth is believed by the community and whose existence is used as the reference in daily activities and behaviors. Thus, local wisdom is an entity that strongly determines the dignity of humans in their community (Geertz, 1992).

One form of local wisdom in the educational context (the student-teacher context) is expressed in the Brahmacari level, i.e., *aguron-guron* or *Asewaka Guru in Acarya* (the teachers who educate their students) by giving spiritual guidances, guidances about virtues, charity, dedication, or collectively called *dharma*. In addition to filling in the minds of the students with various knowledge (*Castrantara*), the teacher gives the first priority to character education (Punyatmadja, 1994).

The classroom teaching can develop the students' characters in order to make the students to become the better ones (Aisah, 2014; Khusniati, 2012; 2014; Dianti, 2014). Based on the issue above, this article will discuss the following points: (1) the aspects of the local wisdom-based character which can be developed in Physics teaching; (2) the methods that are relevant in Physics teaching to develop the students' characters based on local wisdom; and (3) the procedure of Physics teaching that can develop the students' characters based on local wisdom at senior high schools.

## METHODS

This study was a two-year research and development. The first year part of the research was a study which analyzed needs in developing a teaching model and a conceptual model prototype design. The study involved 30 subjects who were senior high school Physics teachers who had taught Physics at least for ten years at senior high schools. The data collection instruments used were questionnaire, observation guide, and interview which had met the validity and reliability requirements. The data were analyzed by using a descriptive-qualitative analysis.

The stage of the analysis of Balinese local wisdoms that were needed as the basis for developing the students' character was preceded by a review of relevant sources, the description of the aspects and indicators. Then the results of this review were incorporated into a questionnaire which was then given to the Physics teachers to be evaluated. The stage of teaching concepts review was done by reviewing relevant literature and focus group discussion (FGD) with senior high school Physics teachers who were selected as the sample of the study. The results were validated by three instructional experts. All of the data were analyzed descriptive-quantitatively.

## RESULTS AND DISCUSSION

The result of the analysis of the needs of local wisdom-based characters which can be developed in senior high school Physics teaching covers: religious, telling the truths and be honest (*satyam*), tolerant (*tat twam asi*), responsible (*sesana/swadharma*), curious, shy, having a preference for working hard and generous, showing a concern and friendliness toward nature, and having the habit of doing self reflection (*mulat sarira*) and the indicators are as shown in Table 1.

**Table 1.** Results of Balinese Local Wisdom-Based National Characters (n=20)

Character Aspect & Indicator	Mean
<b>Religious</b> (Obedient attitude and behavior in practicing the teachings of one's religion)	
Admires the greatness of God for the physical phenomena (natural phenomena) that are astonishing and secret.	4.75
Feels the greatness of God in relation to variations in this world.	4.67
<b>Tells The Truths and Be Honest</b> (The behavior that unites one's thoughts, expressions and acts)	
Willing to express something which one believes to be truer. Honest in doing Physics assignments or tests.	4.83
Open in expressing problems in learning both to one's friends and the teacher.	4.75

Character Aspect & Indicator	Mean
<b>Tolerant (<i>TATTWAMASI, MENYAMA BRAYA</i>)</b>	
(Friendly attitude without discriminating against religions, ethnics, socioeconomic status, and genders)	
Does not discriminate against ethnics, races, religions in doing school assignments.	4.75
Willing to accept different opinions from friends when they are believed to be true.	4,67
<b>Responsible (<i>SESANA</i> or <i>SWADHARMA</i>)</b>	
(Feels and shows a responsible attitude toward tasks and responsibilities)	
Uses time effectively for completing tasks in the classroom and outside of the classroom.	4.83
Does physics assignments carefully and neatly and submits them on time.	4.67
Always tries to find information about physics learning materials from various sources.	4.83
<b>Curious</b>	
(Asks, discusses and investigates/finds out about various events in nature)	
Always reads books on science, technology and culture	4.58
Always wants to try to do an investigation in relation to natural phenomena that are related to Physics.	4.42
Always wants to find out other answers to physics problems being solved	4.08
<b>Jengah</b>	
(Shows a shame attitude and behavior when one fails or cannot do tasks or when one cannot meet one's responsibilities)	
Ashamed if unable to complete the tasks assigned by the teacher	4.75
Ashamed when caught in the act of cheating in a physics test/examination	4.75
Ashamed when one cannot contribute in every learning activity	4.42
<b>Likes to Work Hard and is Generous</b>	
(Does a job until it produces a satisfactory result and gives benefits to oneself and others)	
Diligent in taking up a lesson to get a satisfactory result.	4.75
Likes to help or help friends who need help	4.00
<b>Shows Concern and is Friendly with Nature</b>	
(An attitude and act which shows that one always tries to keep and preserve the natural environment)	
Plans and does various activities to prevent damages to the environment	4.58
Able to make a good decision in preventing and overcoming damages to the environment	4.58
<b>Reflects Oneself (<i>MULAT SARIRA</i>)</b>	
(An attitude and act that shows that one always reflects on the thoughts, expressions, and acts that one has thought, made, and done that one intends to improve in the future)	
Always reflects on what one has done and corrects what one has done wrongly.	4.50
Does not like to find faults with others when having a difficulty or failure.	4.00

The criteria of assessment used to assess the national characters in this study had the score range of 0 – 5 from appropriate/suitable (4,00) to very appropriate/very suitable (5,00). Table 1 shows that there are 9 aspects of good/positive character from Balinese local wisdom/local culture that can be developed in Physics teaching at school, i.e., religious, telling the truths and being honest, tolerant, responsible, curious, jengah, and self-reflecting (*mulat sarira*).

The Balinese local wisdom based characters were sought in the attitudes and behaviors of the people in their daily life which are inspired by the Hindu holy books such as *Begawad gita*, *Regveda*, *Atharwa veda*, *Silakramaning Aguron-guron*, and *Tri Kaya Parisudha*. Other sources obtained from the philosophy that developed in

Bali Community like *Tri Hita Karana*, which means a harmony between human beings and God (religious), human beings and their fellow human beings, and human beings and the universe. Suja (2000) states that the relation between human beings (*Prajah*) and God (*Prajapati*) is based on the concept of Kawula Gusti, which means God is Gusti (the ruler), while human beings are God's servants with their sincere bhakti. The relation between human beings and their fellow human beings is based on the concept of *Tat Twam Asi*, which teaches that all humans are the same. We all (without being restricted by whatever label) are friends *va suduiva kutum bhakam*. As humans, we have to love each others, helps each other, and treat others just like what you want to be treated. The harmony of relation with natu-

re is likened to “*kadi manik ring cecupu*”. Human beings are compared to *manik* (fetus) while the universe to *cecupu* (womb). This concept contains the meaning that human beings live surrounded by nature, and from nature they obtain food or things that they need to be able to live. In this position, it appears that humans live freely in their being bound to nature. Human beings are free to take whatever from the nature, but they are responsible to keep the preservation of nature. If nature damages, then human beings will certainly perish. Based on this consideration, it is fit and proper that human beings have to respect nature.

The holy book, Veda, states “The earth is our mother, we are her children.” (*Atharwaveda, XII*), and “The earth is our mother, and the sky our father” (*Yayurveda, XXV*). All of these local wisdom-based characters in principle are inspired by the Balinese perspective on the universe as stated by Suastra (2017) that the spirituality is found in the cosmic elements (bhuwana agung/macrocosmos) and human as the microcosmic element (buana alit) and humans are responsible to keep the harmony in the relation between humans and God, humans and their fellow humans and humans and nature where they live. *Jengah* (the feeling of shame when one does not succeed in doing something) is an everyday word doing is very commonly uttered by older family members (mostly parents) to the younger (especially children) in the purpose of giving motivation to do something again with harder efforts to succeed. It should be done soon seriously and with the feeling of responsibility in order not to be ashamed for oneself, for the family, and the community (village).

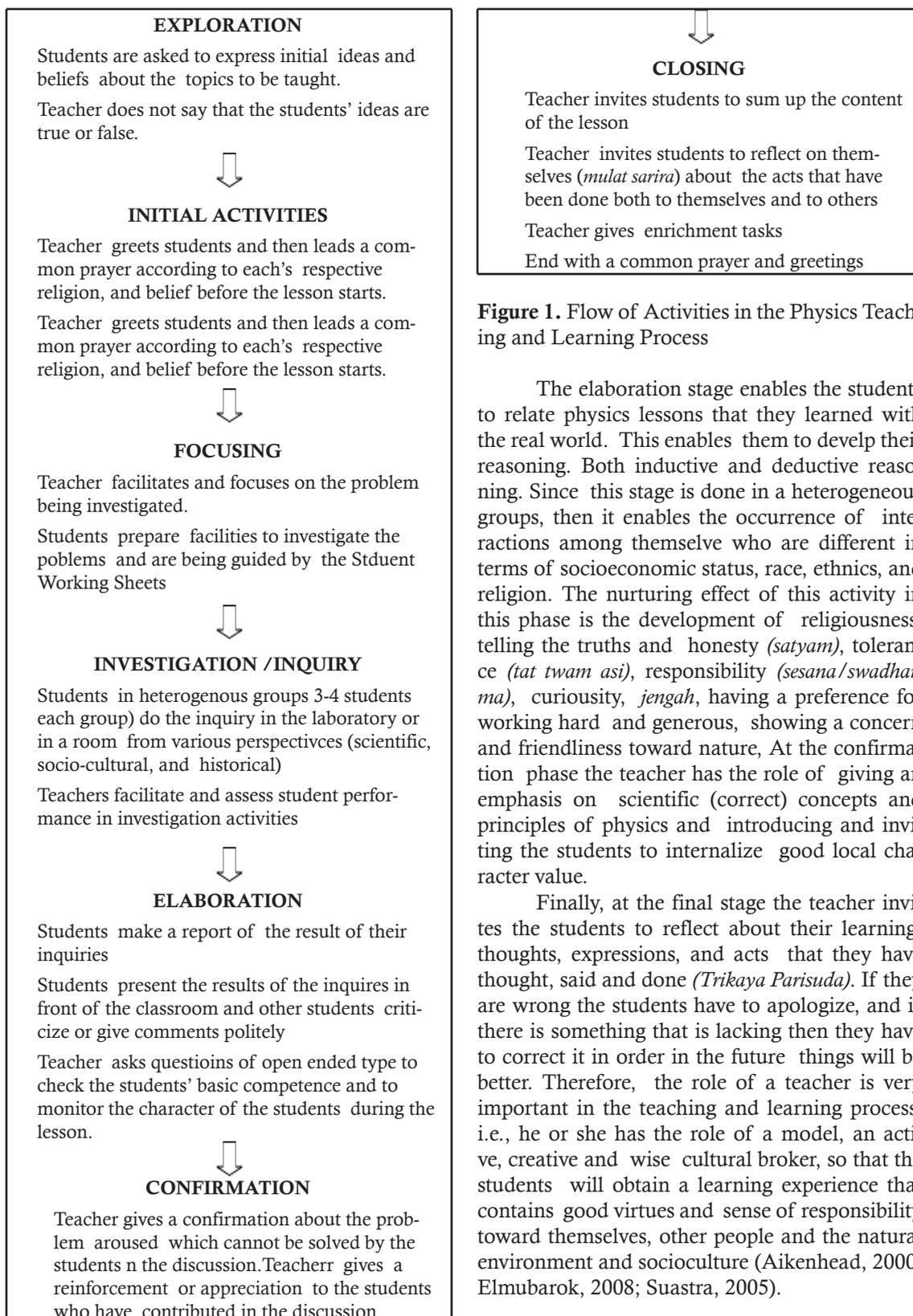
Curiosity comes from the concept in the song as the advice from the elders (father, mother, grandmother, grandfather) to children and grandchildren., *de ngaden awak bisa depang anake ngadani, geginane buka nyambat, ilang luhu buke katah, wiadin ririh enu liu pelajahan*. This is an advice for not to become arrogant when you can do something, like when you are sweeping, the garbage disappears, but dust will come again. No matter how clever you are, there are still many other things that you need to learn since knowledge has no limit. Thus, the message here is that you should not be easily satisfied with the knowledge that you have. Thus the message here

is: you have to learn all your life because there is always something new for you to learn (i.e. long life education).

Based on the result of data analysis, it was found that the methods that can be developed for Physics are inquiry/investigation method (mean=4.75), discussion/question and answer (mean=4.63), and demonstration (mean=4.38). The most appropriate method to be developed is investigation/ inquiry. Inquiry method is the most appropriate for developing science process, critical thinking, and scientific attitudes or scientific character (Hairida, 2016; Harlen, 1992; Neuby, 2010; Sumaji, 1998; Suastra et al., 2011; Neka et al., 2015; Trowbridge & Bybee, 1990; Wenning, 2005; Priyantini et al., 2015; Alpusari & Putra, 2015; Dwianto et al., 2017). Thus, Physics teaching does not only focus on the conceptual, process, and application dimensions, but it has developed the extension of the science education dimensions, i.e., to positive attitude, creativity, and the nature of science itself. (Enger & Yager, 2000); that is physics as product (Van Manen, 2016), physics as process (Van Joolingen et al., 2005), and physics as values (Ismail et al., 2013; Loke & Chow, 2007).

The stages in Physics teaching for developing local culture-based characters are: (a) exploration; (b) focusing; (c) inquiry/investigation from various perspectives (scientific, sociocultural, historical); (d) elaboration; and (e) confirmation and reflection. The stages of physics teaching can be seen in Figure 1.

At the beginning of the lesson the students pray together according to their respective religions and beliefs. This is meant to improve the students' awareness of the greatness of God and to thank God who has created this world with various phenomena that hide mysteries (spiritual character). In the exploration stage the students are invited to make observation, displaying a video or pictures of strange/astonishing natural phenomena (discrepant events), that will develop curiosity in them about the phenomena which will lead to some questions such as what, why, and how it can occur. At this stage, there will develop *jengah* (ashamed when one cannot do or explain something), responsibility, the unflinching habit of telling the truths and being honest and concern about the natural environment.



**Figure 1.** Flow of Activities in the Physics Teaching and Learning Process

The elaboration stage enables the students to relate physics lessons that they learned with the real world. This enables them to develop their reasoning. Both inductive and deductive reasoning. Since this stage is done in a heterogeneous groups, then it enables the occurrence of interactions among themselves who are different in terms of socioeconomic status, race, ethnics, and religion. The nurturing effect of this activity in this phase is the development of religiousness, telling the truths and honesty (*satyam*), tolerance (*tat twam asi*), responsibility (*sesana/swadharma*), curiosity, *jengah*, having a preference for working hard and generous, showing a concern and friendliness toward nature, At the confirmation phase the teacher has the role of giving an emphasis on scientific (correct) concepts and principles of physics and introducing and inviting the students to internalize good local character value.

Finally, at the final stage the teacher invites the students to reflect about their learning, thoughts, expressions, and acts that they have thought, said and done (*Trikaya Parisuda*). If they are wrong the students have to apologize, and if there is something that is lacking then they have to correct it in order in the future things will be better. Therefore, the role of a teacher is very important in the teaching and learning process, i.e., he or she has the role of a model, an active, creative and wise cultural broker, so that the students will obtain a learning experience that contains good virtues and sense of responsibility toward themselves, other people and the natural environment and socioculture (Aikenhead, 2000; Elmubarok, 2008; Suastra, 2005).

## CONCLUSION

There are nine Balinese local wisdom-based characters which can be developed in Physics teaching at senior high school. These characters were sought from various sources as references, advice given by parents to children or the generation after them, and the results of discussions with community leaders and experienced teachers (at least 10 years experience). Conceptually, the core stage of Physics teaching at senior high school to develop characters based on Balinese local wisdom consisted of exploration, focusing, inquiry/investigation, elaboration, and confirmation.

Teacher is very important in the teaching and learning process, i.e. as a model and an active guide, who is active and creative in developing physics knowledge, science process skill, and good students' characters, there is a need to do a research with wider scope with a larger number of respondents and a wider area and the empirical testing of the teaching model at school. There is a need to do a further research to know the effect of the model that has been developed especially in developing the local wisdom based-characters.

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## BUILDING THE CHARACTER OF PRE-SERVICE TEACHERS THROUGH THE LEARNING MODEL OF PROBLEM-BASED ANALYTICAL CHEMISTRY LAB WORK

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### ABSTRACT

This research aims to apply and find out the characteristics of Problem-Based Instrumental Analysis of Chemistry Lab Work Learning Model (IACLLM) which is able to build the characters, improve the conceptual mastery and the ability of problem solving. The research using experimental quasy with 2 student groups of pre service chemistry teachers as the subjects of the research applied the treatment of problem-based IACLLM for the experimental class and lab work learning with standard lab work procedure in control class. Conceptual mastery was measured using essay test; problem solving skills were measured using assessment of problem solving reports, presentation of the results, and kit making products; whereas the emerged characters were observed during the learning process. The result of this research showed that problem-based IACLLM had open-ended problem characteristic, had produced local material kit, and characters were observed in every stage of problem-based learning model. The implementation of the model could improve the spectrometric and electrometric conceptual mastery, the problem solving skills on a very good level and also some characters were developing during learning process, including religious, discipline, honest, curious, creative, critical, cooperative, communicative, independent, and able to appreciate other people's opinions and achievements, leadership, democracy, and able to be thorough and careful, and hardworking.

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**Keywords:** IACLLM; teacher characteristics; problem-based lab

### INTRODUCTION

Lab work in universities is usually conducted during or after theories is given to support and validate students' knowledge on the certain course. The verification of lab work manual with gradually specific directions does not invite students to solve problems, therefore, the students' abilities to actually obtain some facts, as well as concepts of their own findings cannot be realized (Urena et al., 2012; Adani, 2006; Jalil, 2006; Haryani, 2011). Besides that, verification of working procedures in the lab work manual are also less giving opportunities for students to process infor-

mation thoroughly, and students' main concern is only how to finish lab work assignments and report making (Hicks & Bevsek, 2012; McDonnell et al., 2007; Cooper & Urena, 2008). Even twenty years ago, Nakhleh (1996), reminded that chemistry in many parts of the world had invested a big amount of money to give some lab work experiences for students; however, it rarely evaluated on what should be achieved in lab work. Meanwhile, Haryani (2011) recommended that the lab work activities should be able to generate learning motivation, support conceptual mastery, develop basic experimental skills, and improve the skills of problem solving.

It is important for students to be trained on problem solving skills, and students of pre

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service chemistry teacher are needed to face assignments and challenges in the working world. On daily basis, students also often face many complicated problems (ill-structured/unstructured). Some reality that describes the students' low skill in handling problems are shown from the brawls happened between schools and students, drug abuse, and abortion. To overcome this moral crisis, problem solving as one of high level thinking skills is necessary to be trained through well-planned learning. Problem-based lab work learning model is highly assumed to be able to give good learning environment to improve problem solving skills (Haryani, 2011; Urena et al., 2012; Ferreira & Trud, 2012).

The design of lab work learning program does not only pay attention to the aspects of conceptual mastery (cognitive) and basic experimental skills (psychomotoric), but also to the students' affective aspects and problem solving skills. The affective ability is related to the attitude or characteristic of responsible, cooperative, discipline, committing, confident, honest, also related to respecting other people's opinion and having self-control (Aisyah, 2014) (Chan & Bauer, 2016; Popham, 1995). Those values are closely connected to the development of cultural and character education. The formation of strong and solid students' characteristics is very strategic in the nation's sustainability and excellence in the future, as well as very important to be owned by students to face the future challenges. We need to do a lot of efforts to face the challenges seriously, especially now that UNNES has established itself to be a University of Conservation. Conservation here means how UNNES and all academic activities have conservation and concern toward environment, socio-cultural, and conservation on knowledge (science). To enable the learning model of problem-based analytical chemistry lab work supporting conservation and developing students' characteristics, it is necessary in implementing Green Chemistry principles.

Based on arguments described above and according to various research results, the learning of instrumental analysis of chemistry lab work should be conducted so that students are trained to solve problems and grow their scientific attitudes (character education) by giving laboratory experience based on challenging and meaningful research as mentioned in PBL. Problem-Based Instrumental Analysis of Chemistry Lab Work Learning Model (IACLLM) gives a very accommodating environment to achieve its purpose, since the essence of this analytical chemistry as a science is to solve problems (Adani, 2006),

this subject is also a process subject, which has various variables, consisting of several measuring methods (Mataka & Kowalske, 2015; Tosun & Senocak, 2013). Furthermore, to support UNNES as a university of conservation, this problem-based instrumental analysis of chemistry lab work learning model developed is using local material based on Green Chemistry principles. The equipment limitation both in numbers and kinds as well as the expensive materials often become obstacles faced by teachers (Haryani et al., 2010). Therefore, pre service teachers need to be equipped with modeling on how to overcome equipment limitation. The briefing of pre service teachers appropriate with this subject is making simple measurement tools (kit), portable, but the observation data have good responsibility. This capacity of responsibility is obtained by comparing the measurement results using available laboratory instruments.

From previous descriptions, the main problem that becomes the focus of the research is "How do we develop conservation-based character education model through the implementation of problem-based IACLLM using local material". To manifest that idea, a lecture on instrumental analysis chemistry lab work is conducted with the strategy of problem-based instructional learning; that is proven to be able to improve the problem solving and conceptual mastery, as well as to build scientific attitude/character.

## METHODS

This research is an experimental research that outlines the quantitative and qualitative data collection done simultaneously. Experiment class was given problem-based IACLLM treatment, whereas learning in lab work control class was using the standard procedure. This research was conducted in Analytical Chemistry Laboratory in Chemistry Department FMIPA UNNES, with the subjects of one study group as the control group and one study group as the students' experimental group. All were the students of Chemistry Education Department who were having the subject of Instrumental Analysis Chemistry (IAC).

The learning of problem-based IACLLM implemented had four stages, adapted from Arends (2004). The first stage, students were oriented on problems and on the second stage students were organized to study. Next, on the third stage, investigation group was guided; and finally on the fourth stage, the results of problem solving were presented. Before conducting lab work, trai-

ning was given to three lab work assistants and one technician. Lab work assistants were assigned to help the researcher in conducting the lab work, observing during lab work process, and assisting in correcting pre-test and lab work reports.

The quantitative data collection was using essay test to measure conceptual mastery of spectrophotometry and potentiometry. Qualitative data were collected using assessment column; through observation during learning process to encompass the emerged character. Besides that, an interview was conducted to explore the students' knowledge related characters built in every step of problem-based lab work learning. The measurement of problem solving adapted from Fogarty (1997) that covered the assessment of problem solving report, presentation of the results, and kit making products in which all used columns.

Quantitative data in the form of spectrophotometry and potentiometry conceptual mastery of pre service chemistry teacher was analyzed using the formula of normalized gain, while the qualitative data was analyzed using descriptive percentage. After N-gain for the second group was obtained, it was then compared to see the difference of conceptual mastery improvement. The results of the observation were characters emerged and the performance during learning process was analyzed descriptively. Besides that, a supporting interview was also used to see characters built on every problem-based learning step.

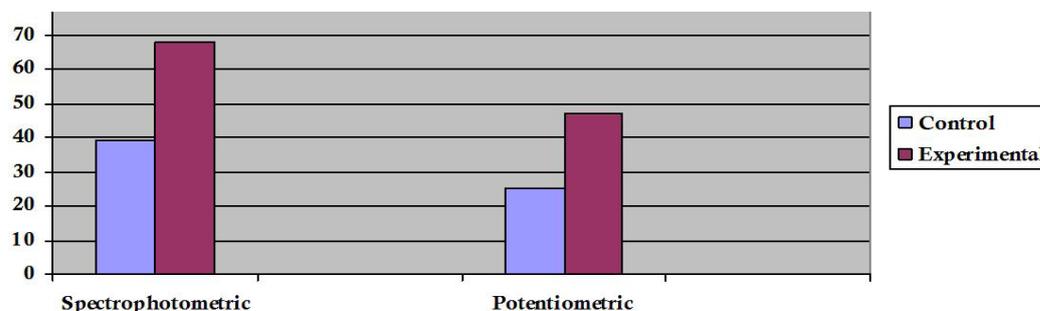
## RESULTS AND DISCUSSION

The learning of problem-based IACLLM in this research was designed to improve the conceptual mastery of spectrophotometry and potentiometry materials, problem solving skills, and develop students and teachers' characters. The initial step in the problem-based IACLLM was to have students oriented on the problems. Problems

were categorized into groups according to available instruments/tools; it can be from students or teachers. Next, in groups, students decided the title of the research with these results: (1) The determination of Acid-Base pH using Natural Indicator Stick with Kit aid Simple Experiment; (2) The Making of Simple Comparative Electrode Kit of Ag/AgCl using Jelly Membrane; (3) The Used Battery Utilization as A Simple Conductor; (4) The Determination of Pb Level in Drinking Water; (5) Simple Test for Fabric Dyes in various drinks in Primary School; (6) Semi quantitative Urine Test for Diabetic Mellitus Patients; and (7) Qualitative Test of Formalin and Borax content in Foods (Meatball and Dumplings).

Figure 1 shows the percentage of N-gain from the conceptual mastery of spectrophotometry and potentiometry as a whole concept in control and experimental groups. The data from both groups were normally distributed, with variants of % N-gain between homogenous groups. The results of % N-gain from control and experimental groups each for spectrophotometry and potentiometry were shown in Figure 1. Although 3 from 4 data were included in medium category, but the result achievement of this % N-gain was quite meaningful, supported by the different test result that % N-gain from the learning of problem-based instrumental analytic of chemistry lab work showed a significant difference ( $p < 0.05$ ).

Table 1 shows the average % N-gain on every concept of spectrophotometry and potentiometry materials in control group and experimental group. The average result of % N-gain spectrophotometry material from experimental group was categorized as medium with two concepts categorized as high, while for various control groups; the average was categorized as medium with each concept categorized as low and medium. In contrast to spectrophotometry, the average % N-gain from control group potentiometry was categorized low, whereas experimental group was categorized medium.



**Figure 1.** The average % N-gain from Students' Conceptual Mastery as A Whole between Control Group and Experiment Group in Spectrophotometry and Potentiometry Materials

Based on the finding of the research, it seemed that spectrophotometry and potentiometry of problem-based IACLLM provided a good learning environment to improve the conceptual mastery of pre service teacher. The learning was initiated by students' orientation stage on problems. Students, in groups, were asked to solve open-ended problems in a laboratory research project, and were ended by presentation of the results and display of the research posters. The

improvement of conceptual mastery was varied for each concept, but the average of all including medium category for both experiment and class control showed a significant difference (Table 1). Based on the comparison of pre-test and post-test results, there are not any students whose conceptual mastery decreased, as well as remained stable. Although there were various improvements, the data obtained showed that there was a successful improvement (medium category).

**Table 1.** Data of % N-gain from every spectrophotometry and potentiometry concepts of control and experiment groups

Concept	% N-gain	
	Control	Experiment
<b>Spectrophotometry</b>		
Basic principles of spectrophotometry	39,05	79,00
Spectrophotometry classification	39,75	69,00
Spectrophotometry components	39,50	72,15
Lambert Beer Law	49,24	67,00
Sample preparation	36,22	68,50
The difference between atom dan molecule spectrophotometry	35,08	54,50
Standard solution production	34,35	63,56
Level measurement	33,00	62,08
<b>Potensiometri</b>		
Electrochemistry cells	20,05	40,00
Electrode potential	32,65	48,05
Nernst equation	33,75	46,55
Comparative electrode	19,85	41,50
Indicator electrode	19,67	40,50
Quantitative aspect	20,50	63,16
Potentiometric titration	16,50	40,00

In Table 1, it was shown that the highest % N-gain of conceptual mastery occurred on the basic principles of spectrophotometry and the lowest was on the difference of molecule and atom spectrophotometry. The highest potentiometry was quantitative aspect/Faraday law, and the lowest was potentiometric titration.

The acquisition of the highest improvement for basic principles of spectrophotometry was because in this concept students started to write theoretical study both in their proposals and research reports, so that students got their learning experience directly that caused memory of event, a description of experience having long term effect more optimally (Hackathorn et al., 2011). This result was the revision from the research result of Haryani (2011), with the lowest % N-gain. This success was strongly assumed because at the presentation, students were asked to

write the basic principles of measurement. Then, the low % N-gain of understanding and difference of molecule and atom spectrophotometry, were suspected because at the start of problem solving orientation stage, students focused more on the searching procedure related with problems to be solved. Besides that, this concept was accidentally written on literature review during proposal writing as it was in the concept of spectrophotometry basic principles.

The achievement of the highest concept in potentiometry was quantitative aspect/Faraday law. This concept was learned frequently started from Basic Chemistry, Basic of Analytical Chemistry, and on other skillful group such as Physics Chemistry. On the contrary, the low potentiometric titration concept was assumed that because students were lacked of skills in changing the initial data to be the first and second

derivative data, which was prepared to make curves. Besides that, students were generally weak in volumetric titration that became prerequisite of this material.

For both spectrophotometry and potentiometry materials, the concept that directly connected to the research procedure had been relatively good in results, this was corresponding with the previous research findings (Haryani, 2011). The obtained value of spectrophotometry was higher than potentiometry; it was possible that the analysis using spectrophotometry methods was also obtained through organic chemistry lab work, as well as an organic chemistry. Besides that, students also got spectroscopy material from Physics Chemistry subject.

On the contrary, the highest improvement of % N-gain for control group which was directly connected with the implementation of lab work was relatively low compared with the basic concepts which were not directly related with the lab work. The highest improvement of % N-gain for control group occurred in Lambert-Beer law, and the lowest one occurred in the measurement concept of level determination. The low level of level measurement concept was possible because during the report making, students adopted their senior's works; also, they were required to present their results. Besides the measurement of level determination, % N-gain whose improvement was relatively low in the control group was the production of standard solution. In every lab work, students were given tasks in groups to prepare pre-reaction before the lab work. However, so far the standard solution in spectrophotometry was prepared by one group, and the other groups were only measuring its absorbance. That was why it was normal for the bad quality of the improvement result. The tasks given to certain groups in

preparing the standard solution was meant to save the time as well as to save the standard solution of titrisol which was frequently used.

The findings in this research showed that problem-based IACLLM provided a good learning environment in improving the students mastery on spectrophotometry and potentiometry materials; and these results were in accordance with the findings reported before (Tandogan & Tandogan, 2007; Hicks & Bevsek, 2012). In the problem orientation, students in groups will be given open-ended problems that would encourage students' curiosity and motivate them to be able to solve problems (Urena et al., 2012). According to Tan (2003), evidences recommended that problem-based learning could improve students in constructing knowledge and reasoning ability compared with the traditional teaching approach. Akcay (2009) on the other hand, revealed that problem-based learning was derived from constructivism learning; it was the learners constructed knowledge actively.

The data of problem solving from students of experimental group showed were obtained from reports/results of the problem solving, and the kit product as results of problem solving with the average were simultaneously 85; 86,12; and 86,11, and the whole average was 85,75. Based on the results obtained, it showed that the total score of problem solving reached the highest criteria; it was that each aspect was bigger than 85%. The indicator of minimum success in this research was 80%. Indicators for the report of problem solving referred to the pattern of problem solving which was developed by Fogarty (1997). The problem solving skills were measured as a whole through the working performance assessment using column. Table 2 shows the score summary of problem solving results.

**Table 2.** The summary of problem solving score of experimental group

Groups	Reports	Presentations	Products	Average
I	86,50	87,71	87,71	87,31
II	85,33	86,72	86,72	86,26
III	85,17	86,14	86,14	85,82
IV	85,00	85,86	85,86	85,57
V	84,00	84,67	84,67	84,45
VI	84,23	85,65	85,65	85,17
VII	84,25	85,81	85,80	85,28
VII	85,50	86,40	86,40	86,10
Mean	85,00	86,12	86,11	85,75

To enable solving the unstructured, contextual, and open-ended problems in PBL, students must be digging up and understanding much information; students must also design and do some researches in order to do problem solving. Students must become “architect” for the learning process they did. However, students were used to do learning method of “listen and take some notes as well as do actions whenever there is an instruction from the lecturers”. The implementation of problem-based IACLLM accompanied with the measurement tools of this problem solving, students obtained lab work learning model directly that would be very useful to be applied in the future (Hicks & Bevsek, 2012; McDonnell et al., 2007).

The observation results by observers (research members) toward the learning conducted by a lecturer (the head of research) showed that the relevant problem presented with competency learned in the lecture, accurate lecture time management, and students cooperation were doing well. Meanwhile, students’ motivation to discuss, ask questions, communicate, argue, facilitate, lead the discussion, and responsible in learning were still needed to be improved.

The use of unstructured, contextual, and open-ended problems, in fact, could improve students’ skills in problem solving. These problems could trigger students to be involved actively in group discussion to find and determine the best problem solving for the groups. This learning required students to use their intelligence to decide real issues started with defining problems, collecting useful information, restating problems, producing alternatives, suggesting solutions, and determining recommendation (Urena et al., 2012). Besides that, these problems could also train students to solve contextual problems so that they had experience in solving problems that they faced in their real lives. This finding was in accordance with the previous finding (Gunter & Alpat, 2017; Ferreira & Trud, 2012; Akcay, 2009; Demirel & Dagar, 2015; Downing, 2010; Bilgin et al., 2009).

Students’ characteristics developed through problem-based lab work were obtained from the observation results during learning process in every meeting using students’ observation form. There was also interview in every learning stage. Based on that observation, analysis was then conducted toward the emerged/developed character, and the percentage of its emerging/development was counted in every PBL step.

Character of discipline was observed and built through punctuality in attending the lec-

ture according to the deal agreed during lecture; wearing lab work coat; borrowing equipments; arranging lab work timetable, and collecting the lab work report. This discipline aspect emerged started from introduction until stage four with the total average of 90%. Meanwhile, religious aspect also emerged started from introduction until stage four, which was built by greeting in the beginning and at the end of lecture as well as praying with the total average of 95%.

Students’ curiosity detected, started from the introduction stage, was the curiosity of how an unknown thing worked, stage one and two during the problem given, from the proposed questions especially about how to find procedure and determine the proper procedure from all procedures obtained. Besides that, curiosity was also detected on stage three during the consultation of observation data. The average percentage of curiosity aspect appearance was 60. Next, honest characteristic was observed and built on stage three and . Honesty could be built through how students measured materials, as well as borrow some equipments. Students must be honest whenever they did mistakes in laboratory; such as telling the truth when they broke glasses, and telling the real report and presenting results based on data. For this honest aspect, the total average obtained was 90%.

Thinking critically and creatively occurred in stage one and two. Students were demanded to think critically while doing exercises/pre-test and thinking about the problems and how to solve them. Students should also think creatively, while choosing effective and efficient types of lab work/ research so they could obtain the result maximally. They should also creatively design products to make KIT. The total averages of critical and creative thinking were 60 and 80% respectively.

Cooperating appeared on stage two until four. Students must cooperate in their groups to find working procedure, also to do lab work in order to solve problems. Leading characteristic was also built on stage two until stage four, started from task division on finding information to design proposal until lab work arrangement. The total average for cooperative and leading characteristic were 90 and 60% respectively.

The characteristics of hardworking, independent, thorough and careful were dominantly built on stage three. Lab work to solve problems really needed hard work in achieving the experimental purpose. This hard work was carried out by students started from doing preparation/sample preparation in experimental activities.

Students were demanded to be able to make solution independently based on the task division from their own groups. In preparing the equipments which were going to be used, they must be careful because the equipments were made from glasses; if they were not careful, those equipments would endanger themselves and people around them. It was also applied to chemicals; they must always be careful since some chemicals were corrosive, poisonous, and could cause itchy on their hands if they touched them; and some were even flammable. Next, for careful characteristic, it was built when the practitioner prepared some materials such as measuring substances, measuring the volume of solution, and observing results. The total averages for hardworking, independent, thorough and careful characteristics were 90; 80; 90; and 90% respectively.

On stage three, students communicated their observation result both in tables and figures. This communicative characteristic was also built by communicating the research result through report writing, power point making, as well as oral presentation which occurred on stage four. The total average for communicating was 80%. Next, another character built on stage four was democratic, respecting friends' opinions, and other people's achievement. While students are performing their presentation on their experimental results, they practiced receiving inputs from other groups. During discussion of paper or power point making, students learned democracy and respect their friends' opinion in their groups. Respecting friends' achievement also happened especially in products produced by other groups by granting more score. The total average for democratic characteristic, respecting friends' opinion, and respecting other people's achievement was 80%, 40%, and 60% respectively.

The improvement of conceptual mastery for this research was followed by problem solving skills with high scores and at least 16 characteristics were built through PBL steps. This learning success in cognitive domain and psychomotoric were influenced by scientific attitudes from the students as well as were determining someone's success in learning (Popham, 1995). Next, Popham stated that according to some expertise, someone's shifted attitudes or characteristics could be predicted if he/she had already had high cognitive mastery. This research result was in accordance with the results of some researches (Kelly & Finlayson, 2009), in that PBL besides improving conceptual mastery, it was also improving the social skills such as teamwork, confidence, and interactive manner with other people, and

communication. Besides that, problem-based lab work learning also improved the students' skills in being careful with chemicals, doing careful observation, and trying to find information related with lab work conducted. Generally, students' responses toward learning implementation was very positive, they are: (a) improving their involvement; (b) giving direct experience through modeling; (c) practicing on doing great experiments; and (d) expecting that it could be applied on other lab work.

## CONCLUSION

Based on research results and discussion, it could be concluded as follows. First, instrumental analysis of chemistry lab work learning model which was developed adapted problem-based learning steps, possessed these characteristics: (a) open-ended problems related spectrophotometry and potentiometry materials; (b) kit from problem solving was produced using 7 local materials; (c) characters were observed and interview was conducted on every problem-based learning step; (d) problem solving was measured through reports of problem solving, presentation of problem solving results, and products of problem solving results. Second, the implementation of problem-based IACLLM model using local material could both improve conceptual mastery and increase the skills of problem solving for pre service teachers in a very good category. Third, the characteristics developed in problem-based IACLLM using local material were: religious, discipline, curious, creative, critical cooperative, respectful for other people's opinions and achievements, democratic, thorough, careful, and hardworking. Students gave positive response toward the implementation of IACLLM.

Based on the results achieved in this research, these recommendations can be made. The implementation enlargement of problem-based lab work learning for other lab work subjects needed to be done, remembering that around 50% of Skill Subjects were followed by lab work; so that it would have a good potency to give academic atmosphere in order to achieve the competency of pre service chemistry teacher through lab work. The lecturer for lab work subject must always innovate to change the verification-based lab work paradigm to be problem-based lab work, by digging more ideas with students in finding open-ended and contextual problems hoping that it could color students' characteristics both as a person and as a teacher as his duty.

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## PROJECT- BASED LEARNING AND PROBLEM- BASED LEARNING: ARE THEY EFFECTIVE TO IMPROVE STUDENT'S THINKING SKILLS?

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### ABSTRACT

The study aims at finding (1) the effect of project-based learning and problem-based learning on student's creativity and critical thinking and (2) the difference effect of project-based learning and problem-based learning on student's creativity and critical thinking. This study is quasi experiment using non-equivalent control-group design. Research population of this study was all classes in eleventh grade of mathematics and natural science program of SMA N 1 Temanggung. The participants were 102 students. This study used three classes as research sample which implemented three different kinds of learning models in respiratory system. XI MIPA 3 was as an experimental group implementing project- based learning and XI MIPA 5 was as an experimental group implementing problem- based learning, while XI MIPA 1 was as control group. Data was collected using two instruments to measure student's creativity and student's critical thinking. Data was analysed using t- test, multivariate analysis, and univariate analysis. The results reveal that (1) project-based learning and problem-based learning affect student's creativity and critical thinking; (2) there is a difference effect of project-based learning and problem- based learning on student's creativity; and (3) there is no difference effect of project-based learning and problem-based learning on student's critical thinking.

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**Keywords:** project- based learning; problem-based learning; creativity; critical thinking; respiratory system

### INTRODUCTION

The changing times that require individuals to master 21<sup>st</sup> century skills have an impact on education. The impact is a change in the learning activities. Learning in the 21<sup>st</sup> century should ensure students to have 21<sup>st</sup> century skills including skills, work habits, and characters that are believed to be essential to achieve successful life. Learning activities must ensure that students have (1) learning and innovation skills including critical thinking skills and problem solving, communication and collaboration, creativity and innovation; (2) information, media, and technology skills; and (3) life and career skills (Trilling & Fadel, 2009). To achieve these skills, students

require an educational program that is capable in developing human resources in order to become a competitive personal.

In response to the changes in learning due to the demands of 21<sup>st</sup> century skills, the Indonesian government develops the 2013 curriculum. The 2013 Curriculum adapts concepts of 21<sup>st</sup> century skills, scientific approach, and authentic assessment. One concept adapted in the curriculum is the concept of a scientific approach that includes several learning models. The learning models recommended by the 2013 Curriculum are project-based learning, problem-based learning, discovery learning, and guided inquiry. The application of these learning models is expected to develop student's skill especially student's thinking skills, creativity, and critical thinking.

Learning in schools should be able to develop student's skills, one of which is the deve-

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lopment of creativity. Creativity development aims to prepare students in facing the challenges of the working world (Kind & Kind, 2007). In fact, student's creativity development in schools is still not optimal. Lack of attention to the development of creativity is caused by the notion that creativity cannot be learned and measured. Trilling & Fadel (2009) states that creativity can be learned in a learning environment that supports questions, patience, openness to new ideas, high trust, and learning from mistakes and failures. Creativity can be developed with continuous practice. One of the most effective ways to develop creativity is by learning through projects in order to find solutions to real-world problems.

PBL does not only equip the students with knowledge but also improve their problem-solving skill, critical and creative skill, lifetime learning, communication skill, team work, adaptation to changes, and self-evaluation (Khoiri et al., 2013). In PBL, the realworld problems is used to motivate the students through the problems (Farhan & Retnawati, 2014). When solving the problems, there will be information exchange between student and other students so that the problems can be overcome. Teachers act as facilitators to direct the problems so that the students' discussion is focused on the solution (Wulandari, 2013). According to Hartini (2014), there is significant influence of kreatif thinking on students' learning outcomes when Problem-Based Learning is implemented.

The development of science curriculum especially Biology curriculum aims to develop student's thinking skills, specifically critical thinking. Critical thinking skills is the ability to interpret data, make inferences, explain information clearly, analyse, and evaluate. However, student's critical thinking skill is not yet fully developed. Therefore, based on the demands of the 21<sup>st</sup> century, especially creativity and critical thinking, it is necessary to develop learning activities in schools that are able to enhance student's skill in order to achieve 21<sup>st</sup> century skills. Learning activities that are relevant to learning in the 21<sup>st</sup> century are project-based learning and problem-based learning. Both models of learning are equally presented issues brought from the real world. Authentic issues presented at the beginning of the lesson are made into problems that must be solved by students either individually or groups.

Implementation of project-based learning in Biology learning can be done by conducting

project-based learning syntax written in lesson plans. The syntax of project-based learning by Bender (2012) are 1) introduction and team planning the project; 2) initial research phase in term of gathering information; 3) creation, development, initial evaluation of presentation, and prototype artifacts; 4) second research phase; 5) final presentation development; and 6) publication of product or artifacts.

In addition, project-based learning and problem-based learning models can be used to develop 21<sup>st</sup> century skills. Problem-based learning is a teaching model using problems as a main focus for developing problem-solving skills, materials, and self-organization (Kauchak & Eggen, 2012). The problems used in this model of learning are real world problems (Arends, 2007; Fogarty, 1997). Problems encourage students to share knowledge, negotiate alternative ideas, seek information, and construct arguments to support established solutions (Sawyer, 2014).

Problem-based learning can be applied in learning Biology by following syntax of the learning model. Problem-based learning begins with 1) problem orientation; 2) organizing students to conduct research; 3) assisting independent and group investigations; 4) developing and presenting artefacts; and 5) analysing and evaluating problem solving process (Arend, 2007). During the learning activities, teachers play a role in providing problems, asking questions, and facilitating investigations and dialogue.

The material used in this research is respiratory system including competence 3.8 and competence 4.8. Competence 3.8 mentioned that students are required to analyse the relationship between the structure of the respiratory system and its relation to bioprocess and disfunction that can occur in the human respiration system. In competence 4.8, it is added that students are also trained to present the analysis result from the effect of air pollution to the respiratory disorder based on literature review.

Respiratory system material is chosen as a material in this research, because it is adjusted to the research context which is located in SMA Negeri 1 Temanggung. According to data from Directorate General of Plantation in 2014, Temanggung Regency is one of the largest regency that has tobacco (*Nicotiana tabacum*) plantation in Central Java Province. Temanggung Regency has 15,730 Ha of tobacco plantation. Harvested reaches 12,587 Ha. Tobacco production reached 6,923 tons and productivity reached 550 Kg/Ha.

Aside from being a tobacco producer, data from the Central Java Provincial Health Office (2014) shows that in 2014, there are several respiratory system disease caused by bacteria or infection, such as tuberculosis and pneumonia.

Problems used in project-based learning and problem-based learning are associated to respiratory system. By learning using project, students are faced with the essential question of how activities affect human lung capacity and how to reduce smoking habits. Based on information obtained by students from various sources during the learning activities, students are asked to design and test tools to measure the lung capacity and also make posters to reduce cigarette consumption.

In problem-based learning, students are faced with problems in the respiratory system associated with smoking habits. Students will investigate the influence of cigarette smoke and cigarette content by doing a simple experiment. After investigating and analysing the results of the investigation, students discuss diseases that may infect the respiratory system and seek a preventive solution from respiratory disease and then present the solution obtained. Therefore, students are expected to develop creativity and critical thinking skills by learning through project-based learning and problem-based learning.

After the observation, there were some problems found such as project-based learning and problem-based learning were rarely implemented in learning Biology at school. In addition, empirical evidence of the influence of project-based learning model and problem-based learning on the ability of students was limited. Moreover, student's creativity ability was low, shown by high tendency of similarity in doing tasks given by teacher. The critical thinking ability of the students was low, it was shown by the lack of analytical skills in answering questions asked by teachers during the learning activities.

Furthermore, the development of student's creativity was low because of lack of encouragement. Learning activities in schools has not yet developed student's critical thinking optimally. More importantly, the development of creativity and critical thinking of students on learning Biology has not been a serious concern in the learning activities. Moreover, based on the previous research, learning biology using project-based learning can enhance learning activities and student's creativity (Yahya, 2014). It is also able to develop three learning domain namely cognitive, affective, and psychomotor (Sumarni et al., 2016).

The study aims to find (1) the effect of project-based learning and problem-based learning on student's creativity and critical thinking and (2) the difference effect of project-based learning and problem-based learning on student's creativity and critical thinking in respiratory system at SMA N 1 Temanggung.

This research is expected to provide benefits either directly or indirectly to teachers, students, and other researchers. Teachers can enrich the learning model such as project-based learning model and problem-based learning in Biology learning. Students can improve thinking skills, such as creativity and critical thinking, and also can apply the knowledge gained during the learning activities in everyday life. In addition, other researchers can get information about the effect of project-based learning and problem-based learning to student's creativity and critical thinking, so that it can be beneficial for further research.

## METHODS

This research is quasi-experimental research using nonequivalent control-group design (Gall, et al., 2007). The quasi experimental design used in this research is non-equivalent control-group design. The research was conducted at SMA Negeri 1 Temanggung, Temanggung Regency, Central Java from January to February 2017. The population of this research is the entire class of IX grade of Mathematics and Natural Sciences Program which is divided into 7 classes. The sample of this research is 3 classes taken randomly from IX grade of Mathematics and Natural Sciences Program. XI MIPA 3 implemented project-based learning model, class XI implemented problem-based learning model, and class XI MIPA implemented 5M learning model as a control group.

Data collected in this research consists of learning implementation data, student's creativity data, and student's critical thinking data. Learning implementation data were obtained from the observation sheet which was developed based on the lesson plan. The project-based learning model begins with 1) introduction and team planing the project; 2) initial research phase in term of gathering information; 3) creation, development, initial evaluation of presentation, and prototype artifacts; 4) second research phase, 5) final presentation development; and 6) publication of product or artifacts. Problem-based learning model begins with 1) problem orientation; 2) organizing students to conduct research; 3) assisting independent and group investigations; 4) developing

and presenting artefacts; and 5) analysing and evaluating problem solving process.

Student’s creativity data and student’s critical thinking data were obtained using the instruments of creativity and critical thinking. Aspects measured in creativity consist of unusual uses, sensitivity to science problems, the ability to develop the product, the ability in scientific imagination, creative problem-solving skills, experimental design abilities, and the ability to design products. Aspects measured in critical thinking consist of the ability to make interpretation, ana-

lysis, inference, evaluation, and explanation. To know the effect of project-based learning model and problem-based learning model to student’s creativity and critical thinking, data were analysed using paired sample t-test. The test was conducted on two paired samples. Furthermore, to analysis two groups of data simultaneously, data were analysed using MANOVA. Before data were analysed using MANOVA. Data had to meet the assumptions test which consists of normality and homogeneity test.

**Table 1.** The Results of Descriptive Statistic on Student’s Creativity

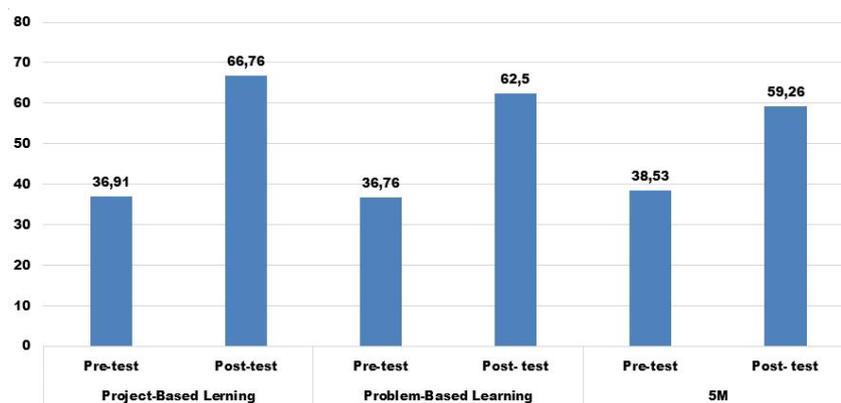
Descriptive Statistic Result	Experiment				Control	
	PjBL		PBL		5M	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Mean	44,01	70,38	46,85	59,77	35,40	59,45
STDV	11,45	11,38	11,69	16,05	14,46	17,07

**RESULTS AND DISCUSSION**

This research was conducted on respiration system material in XI grade. It was divided into 6 meetings. Based on observation, project-based learning and problem-based learning model were implemented accordingly to lesson plan. The learning activities was started with pre-test and ended with post-test. Pre-test was conducted to obtain student’s creativity and critical thinking data before the treatment. In the end of learning activities, post-test was conducted to obtain student’s creativity and critical thinking after the treatment. Both pre-test and post-test were imple-

mented using the creativity test and critical thinking test that have been developed. Table 1 shows the results of descriptive statistics of students’ pre-test and post- test of creativity.

Based on the data presented in the table, it can be concluded that the average on student’s creativity increase in project-based learning class, problem-based learning class, and 5M class. The data of student’s critical thinking ability was obtained from pre-test and post-test of student’s critical thinking. Figure 1 shows the results of descriptive statistics of pre-test and post-test of critical thinking of students.



**Figure 1.** The Results of Descriptive Statistic on Student’s Critical Thinking

Based on the results of descriptive analysis, it can be concluded that the average critical thinking ability of students has increased after following the learning activities with project-based learning model, problem-based learning model, and 5 M. Data analysis was conducted by compa-

ring mean of each dependent variable measured in terms of student’s creativity and critical thinking skills. The comparison of mean data before and after treatment aims to test the mean equality between experimental class in project-based learning and problem-based learning, and control

class by using 5M learning on student's creativity and critical thinking simultaneously. The mean comparison is also conducted only on the mean post-test of student's creativity and critical thinking skills.

The comparison of post-test mean aims to test the hypothesis of the effect of each learning model on each dependent variable; creativity and critical thinking skills. The mean comparison aims to determine the comparison between the effect of project-based learning model and problem-based learning, the comparison between project-based learning and 5M, and the comparison between the problem-based learning model and 5M to the student's creativity and critical thinking skills on the learning of Biology especially regarding respiratory system.

To know the effect of learning models; project based learning model, problem-based learning, and 5M to creativity and critical thinking skill of students, paired-sample t-test was conducted. This test was performed in order to know the difference between student's creative and critical thinking skills before and after the treatment. Table 2 shows the result of paired sample t-test

**Table 2.** The Result of Paired Sample T-Test

Dependent Variable	Learning Model	Sig.
Creativity	PjBL	0,000
	PBL	0,000
	5M	0,000
Critical Thinking	PjBL	0,000
	PBL	0,000
	5M	0,000

Based on the results of paired sample t test, the result, both creativity and critical thinking skills in project-based learning model, problem-based learning model, and 5M show significant difference, which was indicated by significance value 0,000 (Sig. = <0.05). This means that the average value of pre-test with post-test is different. It can be concluded that both project-based learning and problem-based learning affect student's creativity and critical thinking.

To investigate the difference of learning effect using project based learning, problem-based learning, and 5M model on student's cre-

ativity and thinking skill, multivariate test was conducted and continued by univariate test to determine which variables contribute to the overall difference. Prior to the multivariate test, a prerequisite test was conducted including normality and homogeneity tests. Based on the results of normality test with Kolmogorov-Smirnov on pre-test creativity and critical thinking results, it showed that the data of pre-test creativity result of the three groups is distributed normally showed by significance value above 0,05. Based on homogeneity test results based on Box's Test of Equality of Covariance Matrices shows that pre-test data has homogeneous population data variance indicated by a significance value greater than 0.05.

Multivariate test was conducted to know the effect of learning model that was project-based learning, problem-based learning, and 5M to creativity and critical thinking ability of students simultaneously. Multivariate tests were performed for post-test value of creativity and critical thinking. The multivariate test used was Hotelling's Trace statistics. Hotelling's Trace was used for two groups of dependent variables. In this research there were two dependent variable, such as creativity and critical thinking. Table 3 presents the results of multivariate statistics with the Hotelling's Trace test

**Table 3.** The Results of Multivariate Statistics

Effect	Value	F	Sig.
Learning Model	0,126	3,052	0,018

The result of multivariate analysis using Hotelling's Trace test showed value equal to 0,126, and  $F_{\text{Calculate}}$  equal to 3,052. The value of significance showed the number 0.018 which is smaller than 0.05 so that  $H_0$  is rejected. Based on the results of the analysis it can be concluded that there is an average difference between project-based learning model group, problem-based learning model, and 5M toward creativity and critical thinking ability. After doing multivariate test on result of post-test of creativity and critical thinking ability, then conducted univariate test. Univariate test is conducted on post-test value of student's creativity and critical thinking skills in order to analyse each variable. Table 4 shows the result of univariate test.

**Table 4.** The Result of Univariate Test

Test of Between-Subjects Effects			
Source	Dependent Variable	F	Sig.
Learning Model	Creativity	5,812	0,004
	Critical Thinking	1,885	0,157

Univariate test analysis on post-test value shows that for dependent variable of creativity show  $F_{\text{Calculate}}$  equal to 5,812 and significance value less than 0,05 (Sig = 0,004). These values indicate that the three models of learning have an influence on the creativity of students positively and significantly. As for the ability of creative thinking, univariate test results show  $F_{\text{Calculate}}$  value of 1.885 and significance value greater than 0.05 (Sig = 0.157). These values indicate that the three learning models have no significant effect on creativity in a positive and significant way.

After conducting univariate test, the effect of each model of learning to student's creativity and critical thinking was tested. The tests were performed on each mean of the creativity and ability of the students' post-test by using the Tukey test. The result shows that the significance value of project-based learning model and problem based learning model is smaller than 0.05 (Sig = 0.012) which means that there is a significant difference of creativity average on both learning models. The result of the analysis for the project based learning model and 5M shows the significance value less than 0.05 (Sig = 0.010) which means that there is difference of creativity average of both learning model. The test results on the model of problem-based learning and 5M shows a significance value above 0.05 (Sig=0.996) which means that there is no difference in the creativity average of the two learning models.

Based on the results of Tukey's test analysis for the effect of learning model of critical thinking, it is also known that the significance value for project-based learning model and problem-based learning model is greater than 0.05 (Sig = 0.516). The significance value means that there is no difference in the average of critical thinking of both learning models. The significance values greater than 0.05 also occur for project-based learning and 5M (Sig.=0.134) and problem-based learning and 5M (Sig.=0,682) models. The value of significance means that there is no difference in the average of critical thinking in the learning models.

Project-based learning is one of the suggested learning models to be implemented in learning Biology. It can encourage students to create

project whether individually or in groups. Other learning model such as problem-based learning are also proposed to be implemented in Biology learning. These alternative learning models provide opportunities for teachers to choose a model of learning accordingly to the characteristics of students and materials. The questions for measuring creativity is included into divergent thinking questions. Divergent thinking questions tend to ask for varied or non-fixed answers rather than only one alternative answer. In this research, questions are arranged based on the local issues. According to Runco (Kaufman & Sternberg, 2011) contextual questions are able to illustrate the behavioural habits of students on the actual conditions.

Based on the data, student's creativity skills in project-based learning class has a higher average post-test than students in problem-based learning class and 5M class. The higher average is influenced by the experience of learning activities experienced using project-based learning model. Creativity in the context of learning begin with the process of sensing and observing problems, making conjectures about problems, assessing, and testing allegations or testing hypotheses. The next process is to change and conduct the testing, and then deliver the results (Torrance, 1979).

Project-based learning begin with 1) introduction and team planing the project, 2) initial research phase in term of gathering information, 3) creation, development, initial evaluation of presentation, and prototype artifacts, 4) second research phase, 5) final presentation development, and 6) publication of product or artifacts (Bender, 2012). The learning of project-based learning that is carried out refers to the driving question (Bender, 2012; Thomas, 2000) which is closely related to the respiration material. Driving question helps students to develop the ability to find solutions actively. The driving question used was how human activities influence the performance of the respiratory system and how efforts can be made to encourage people to reduce smoking habits. Driving questions in the begining of the lessons are broad and not specific, so that students need to make discoveries and innovations by adding questions to make the project more specific.

At the beginning of learning with project-based learning, there is an anchor that is used to be an introduction to the project and also attracts students to the project (Bender, 2012). The anchor used in this lesson was a journal and article as references to make a simple instrument to measure the lung capacity and also posters. During project-based learning, students were encouraged

to identify problems that affect lung frequency and lung capacity. After identifying problems, students developed and designed solutions by designing simple instrument to measure lung capacity. The instrument was made to prove that human's lung capacity was influenced by several factors. Students worked and conducted experiment to measure lung capacity in a group. After conducting experiment, student made report and also presentation. All of those activities were student-centered, students determined and created their own projects in group.

During the learning activities, the role of the teacher is as a facilitator and accompanies the students (Thomas, 2000). Teacher gives advice and feedback in order to improve the projects. Feedback is also obtained from other students or other groups when the project design is presented. Peer-evaluation and feedback from teachers provide opportunities for students to make reflection and improvement on their projects (Bender, 2012; Kean & Kwe 2014). Students work together in groups to complete the project design (Bender, 2012; Mioduser & Betzer, 2007). Students also create a schedule to finish the planned project. After product had been finished, students present the product and also the posters.

The first project in project-based learning was making simple instrument to measure lung capacity. During the process of making instrument, students were trained to be sensitive to the problem that every person has different lung frequency and lung capacity. The differences are caused by various factors. Students were trained to find out and prove the differences of lung frequency and lung capacity. Teacher guided students in designing the instrument. Students were also trained to design products using simple materials and apply scientific principles to obtain accurate measurement results.

The second project was making poster regarding to the danger of smoking. In the second project the students were trained to be sensitive to the smokers in the community. Students were encouraged to create posters as a preventive effort in order to invite the community to avoid the habit of smoking. Poster was made by considering some aspect such as originality, poster component, language, and information accuracy displayed in the poster. Projects can be very beneficial in developing cooperative skills (Collette & Chiappeta, 1989). Peer-assessment shows that the students can work together with the group well. This is indicated by the value given to the questionnaire distributed to the student. In addition,

project work actively encourages students to gather more in-depth knowledge of respiratory material and sharpen skills in research (Kean & Kwe, 2014).

Project-based learning and problem-based learning have different characteristics from various aspects. According to Savin-Baden & Major (2004) differences in project-based learning and problem-based learning can be assessed based on knowledge organization, the form of knowledge, the role of students, the role of the teacher, and the type of activity undertaken during the learning activities. In project-based learning the assignment has been arranged in such a way by teachers (tutor-set or structured tasks), while on problem-based learning the problem is presented openly (open-ended situations and problems). In project based learning knowledge form and practical, while in problem-based learning in the form of contingent and constructed.

The role of teachers and students during the learning activities with project-based learning and problem-based learning are also different. In project based learning the role of teacher as tasks setter and project supervisor and the role of students as completer of project or member of project team that develop solution and strategy. In problem-based learning the role of students is as active participants and inventors and have their own learning experience, while the role of teachers is to provide opportunities for students to learn.

Activities during the learning activities between project-based learning and problem-based learning can also be distinguished. In the project based learning, learning activities focus on problem solving activities and problem management. In problem-based learning, learning activities focus on developing strategies to facilitate teams and learning. Project-based learning conducted in this research was the representation of ideational learning. Ideational learning is a learning that relying on the aspirations of students. Learning is open-ended developing domain that supports uniqueness and expects different learning outcomes (Dettmer, 2006). Projects assigned to students give students the freedom to design and develop products accordingly to their expectation, so that one group and another have different results.

Project-based learning is a constructivistic learning that students can learn maximally if able to construct artefacts so that students can be more involved in learning activities (Grant, 2002). Students learning in project-based learning class

were able to make a good report which consists of title, purpose, theory, tools and materials, procedure, results, discussion and conclusion. In addition, students are able to collect information about the dangers of smoking and put in into the poster as well. Student's creativity can be developed through learning that develops the imaginations by providing opportunities for creative writing and also problem solving that offers a variety of different perspectives.

Learning process provides enough time for students to seek and explore the information needed during the learning activities by utilizing the technology (Burke, 2007). Thus, learning process is expected to enhance aspects of scientific creativity that include aspects of unusual use, sensitivity to science problems, the ability to improve usability and product value, the ability of scientific imagination, creative problem-solving skills, experimental design skills, and designing product. Students learn using problem-based learning have lower creativity average than students in project-based learning class. Learning problem-based learning models are effective when used for long-term learning and improving student's performance, so students show less than optimal results when tested on tests for short term knowledge retention (Strobell & Barneveld, 2009).

Science learning can be used to develop student's higher-order thinking skills such as critical thinking. Critical thinking is a complex thinking process that consists of interpretation, analysis, inference, evaluation, explanation, and self-regulation (Facione, 2011). Critical thinking is referred to as higher-level thinking (higher-level thinking/higher-ordered thinking), which includes the top three capabilities in Bloom's Taxonomy: the ability to analyse, synthesize, and evaluate (Bookhart, 2010; Moore & Stanley, 2010). Development of critical thinking ability can be conducted by open-ended question or divergent question. Open-ended questions are questions that expect many possibilities of correct answers (Collete & Chiappetta, 1994; Subali, 2013). One of the learning models that develops critical thinking skills especially on science is problem-based learning. Problem-based learning presents issues that encourage students to not only thinking about the cause but also thinking about how to solve the problem (Strobel & Barnevel, 2009).

Result shows that there is no significant difference in the student's critical thinking skills in project-based learning, problem-based learning,

and 5M. The results can be caused by many factors, such as learning activities. The learning activities implemented in Biology learning using problem-based learning are conducted accordingly to problem-based learning by Arends (2007). Learning begun with the first phase of learning, which was problem orientation. The second phase was organizing students to research. Students made group and distributed learning tasks according to the issue. The third phase was an independent or group investigation. Teachers encourage students to get the information needed to find solutions to problems by carrying out experiments. After conducting the experiment, students developed presentation about the investigation result and also presented the results of discussions about smoking-related diseases and its prevention. During the discussion, teacher guided student to discuss and give the clarification. At the end of the learning process, teacher helped students to make a reflection about learning activities that had been done.

In problem-based learning, students presented the problem about the effect cigarettes content on human's health. Students were asked to find the cause why the cigarette ingredients are dangerous by investigating and seeking information from various sources. Students then discuss one of the diseases caused by the content in a cigarette that consists of causes and efforts to overcome and prevent the disease. The problems used during the learning activities was an authentic problem. The issues raised in this study was issues related to the impact of substances contained in cigarettes to health.

Problem-based learning is one of the learning models that able to develop student's critical thinking skills. At the beginning of learning, students are faced with incentive problems (Arends, 2007). In this research, problems were presented in the form of articles and video. The problems presented were related to real life problems regarding to problems caused by smoking. The problem is ill-structured that expect more than one solution (Tan, 2009).

During the learning activities the student is guided by the teacher to carry out authentic investigations (Arends, 2007). Investigation is conducted by carrying out a simple experiment. Investigation aims to seek information from the problems presented, because the information presented at the beginning of learning is still limited (Tan, 2009). A simple experiment conducted by students consists of two kinds of experiments

conducted at the fourth meeting. The first experiment was an experiment simulating the danger of cigarette smoke against the respiratory organs. Students used three kinds of cigarettes which were filtered cigarettes, unfiltered cigarettes, and homemade cigarettes. The lungs were simulated using white cotton. Students burnt cigarettes and observe the yellowish stain on cotton. Students then assumed that the more yellow stains on cotton, the more substances in the cigarette that will enter the human lungs.

The second experiment was the effect of tobacco content on the embryo. The embryo used in this experiment was the green bean embryo. Experiment was conducted by growing seeds on a medium that has been previously given tobacco water. In addition, students also grew the seeds in water as a control. Students then observed the growth of seeds for 4 days in a row and saw the difference. After conducting group investigations conducted by experiment, students made report and conducted the discussion to find out the relationship between the experimental results and the issues. The results of group discussions were presented. Students worked together in groups during learning process (Arends, 2007, Hmelo-Silver, 2004), while teacher played a role as a facilitator (Strobel & Barnevel, 2009).

During problem-based learning, student's critical thinking skills can be trained and developed. Mergendoller, Maxwell, & Bellisimo (2006) states that in problem-based learning teachers train students to carry out further research and discovery, but their assignment is not determined by the teacher, so students are freed to design and develop experiments through investigation. During the process of designing the experiment, students are trained to construct questions in order to construct the objectives of the experiment, determine the independent variables and the dependent variables in the experiment, write down the experimental results, and draw conclusions from the experiments. Students who participate in project-based learning have the opportunity to construct their own knowledge, compare it with other students and also select their knowledge while other students collect learning experiences. In addition, students who participating in problem-based learning are able to store knowledge longer, identify causal relationships, and transfer the concept to new problems (Savin-Baden & Major, 2004).

## CONCLUSION

The results reveal that (1) project-based learning and problem-based learning affect student's creativity and critical thinking, (2) there is a difference effect of project-based learning and problem-based learning on student's creativity, and (3) there is no difference effect of project-based learning and problem-based learning on student's critical thinking.

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## SCIENCE INTEGRATED LEARNING MODEL TO ENHANCE THE SCIENTIFIC WORK INDEPENDENCE OF STUDENT TEACHER IN INDIGENOUS KNOWLEDGE TRANSFORMATION

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### ABSTRACT

The scientific work independence is the core competency of student teacher of science. In this research, the effectiveness of the Science Integrated Learning Model (SIL) was measured in term of the scientific work independence of student teacher of science in changing the society's original knowledge into scientific knowledge. The changing was measured through Ethnoscience learning. The experimental method was used with the control group and experimental group in three different universities. The result of the t-test shows a correlation coefficient significance value at  $0.000 < 0.05$ . Therefore, it concludes that there is not any difference between the experimental and control group. However, there is an effect of model application on the independence of the scientific work of student teacher of science.

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**Keywords:** Science Integrated Learning Model; scientific work independence; science student teacher

### INTRODUCTION

The quality of science teachers depends on the achievement of the graduate core competencies from the study program where they study for. Also, the determination of the graduate core competencies is based on the carrying capacity of the study program and the graduate end users. The Science Education Study Program and Science Educators Forum in Indonesia agree that the graduate of science teacher program must have the scientific work independence and able to integrate the original knowledge in society as the nation's identity in learning. The independence in scientific work includes the ability in planning, implementation, and evaluation. Moreover, st-

rong scientific work independence means that every graduate is capable of designing and implementing the science learning based on the results of scientific work (Tahar & Enceng, 2006; Zion, 2008; Topaloglu & Kiyici, 2015).

The scientific work independence can be achieved individually through the activity of planning, discovery, exploration, and finding the knowledge from integrated information sources to obtain a thorough knowledge of science. Besides, based on the Indonesian curriculum, there is a requisite to deliver the science learning material in an integrated way. Therefore, the skill in knowledge integration is necessary for science teacher candidate. The students of science teacher candidate have to master this skill and how to teach it (Lang & Olson, 2000; Lee, & Songer, 2003; Parmin et al. 2016; Purwoko et al., 2017). After

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mastering this skill, they can apply it through learning activity by developing community-based learning resources that are contextually analyzed to produce integrated teaching materials (Robert et al., 1998; Lang & Olson, 2000; Sun & Chee, 2013). According to Ankiewicz & Estelle (2006), the use of community-based integrated learning resources can develop the high curiosity, critical thinking activity, responsible attitude of students in science learning. The community-based learning resources can be obtained from the indigenous knowledge. Moreover, it requires a learning strategy to explore indigenous knowledge to be a scientific knowledge or it is usually called as the Ethnoscience.

Furthermore, the independence of scientific work is oriented for the Science Integrated Learning (SIL) model (Parmin et al., 2016). The SIL model using the independence of scientific work is developed from an open inquiry model which has six stages of learning. The stages are exploration, concept integration, experiment, analysis, action and reflection. According to Detrick (2001), the open inquiry of students is ranging from identifying problems and designing process investigations which are conducted by themselves. In addition, the student must have a finding ability in the learning activity (Zion, 2008). Also, the scientific work through experiment can give the students way to plan and analyze the results in an integrated way (Carol et al., 2013). Science integrated learning towards the learning activities begins with the use of a variety of learning resources to explain the science phenomena (Novi & Parmin, 2012).

In order to achieve the competence on the scientific work independence, a learning material which leads to students' learning activity and has the learning strategy with a principal of integrated science is needed. The result of the previous preliminary study on the students' scientific work independence in Science Education Study Program, Universitas Negeri Semarang shows that the students tend to have the dependency on their lecturer when they do the experimental work; also, they have not shown any original knowledge in local society. These problems represent that there is a necessity for a learning instrument development which is oriented in the achievement of graduate core competencies. According to SIL model, the appropriate way to teach science in order to achieve the independence of scientific work can be conducted through an experiment to test the indigenous knowledge of the community

to be a scientific knowledge. Therefore, this study aims to test the effectiveness of the SIL model implementation to the independence of scientific work in student teacher of science, especially in designing, conducting, and evaluating an experiment. Also, in this research, the independence of scientific work in student teacher of science in terms of changing the indigenous knowledge to be the scientific knowledge through SIL model was assessed.

## METHODS

The research used an experimental method with aims to measure the independence of scientific work of student teacher of sciences in Ethnoscience learning through Science Integrated Learning (SIL) model. The dependent variable was the students' scientific work with the provision of pre-test and post-test in the experimental group and the control group to evaluate the Ethnoscience knowledge. The independence of the scientific work was determined based on the calculation of the ideal mean and ideal standard deviation in the experimental group with SIL model. The research was conducted in the Science Education Program of Study in three colleges (Universitas Negeri Semarang, Universitas Negeri Yogyakarta, and Universitas Negeri Surabaya). Each study program has two classes in each student level. The total of student teacher of science involved in this study was 86 students.

In this research, the data collection was conducted to obtain the effectiveness of SIL model implementation in Ethnoscience learning material. Also, this study aimed to obtain the data of pre-test and post-test in experimental and control groups. Moreover, the independence of scientific work in student teacher of sciences in designing, implementing, and evaluating an experiment after Ethnoscience learning with SIL model application was studied. Further, the indigenous knowledge transformation to scientific knowledge with SIL model application was investigated; and finally, the attitude of student teacher of sciences' student was examined after Ethnoscience learning with SIL model application.

The independence of the scientific work of students has been analyzed using descriptive techniques with ideal criteria namely; ideal mean and ideal standard deviation (Arikunto, 2015). Based on the results of calculation of the classification of ideal mean and ideal standard deviation is referring to Table 1.

**Table 1.** The Classification of Ideal Mean and Ideal Standard Deviation

Category	Range
Very high	$> Mi + (1.5 \times SDi)$
High	$Mi \text{ to } Mi + (1.5 \times SDi)$
Moderate	$Mi - (1.5 \times SDi) \text{ to } Mi$
Low	$< Mi - (1.5 \times SDi)$

The factors that affect the students' independence of scientific work used quantitative descriptive analysis with percentage techniques. Questionnaire responses of students used the Likert scale with four levels, i.e. strongly agree, agree, quite agree, and disagree.

**RESULTS AND DISCUSSION**

In this research, the assessment of the Science Integrated Learning (SIL) model implementation on the students in Ethnoscience learning showed a varied maximum score for each stage according to the number of indicators. The maximum score for each stage, i.e. Exploration (20), Concept Integration (8), Experiment (24), Analysis (8), Action (12) and Reflection (8) as shown in Table 2.

**Table 2.** The Effectiveness of The Stage of SIL Model

SIL syntax	Average Score	Criteria
Exploration	19	Highly effective
Concept Integration	6.90	Effective

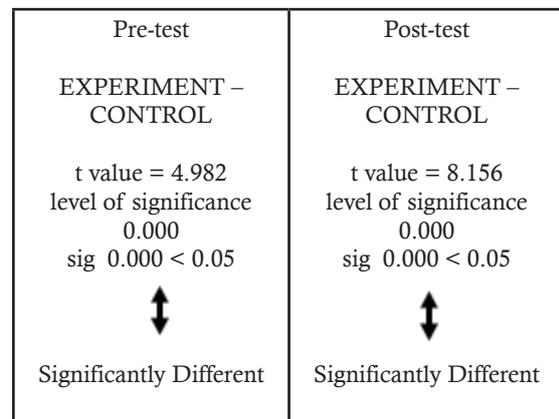
Highly effective criteria were shown in the stage of exploration, experiment, action, and reflection; while effective criteria were found in concept integration and analysis. In summary,

**Table 3.** The Value Difference of Pre-Test and Posttest Results

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair Pre-Test Control 1	-8.71	7.31	.77	-30.24	-27.18	-7.22	89	.000
Post Test Control								

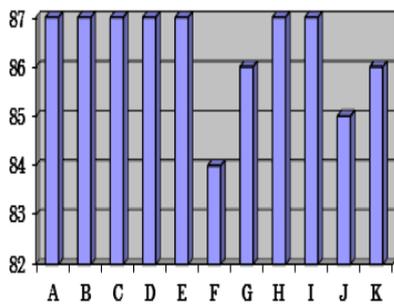
the average of the score was 73. The score represents the application of SIL model in Ethnoscience learning in three universities was effective. The understanding of students to Ethnoscience learning material was also evaluated using test.

The results of pre-test and post-test in experimental and control groups are presented in Figure 1. There is a difference in the results between pre-test of the experimental group and the control group, meaning that there is a difference in the understanding level of Ethnoscience learning material. The experimental group with SIL model application tended to have a better understanding of the learning material comparing with the control group.



**Figure 1.** The Difference of Ethnoscience Knowledge in The Experimental and Control Groups

Table 3 shows the difference of the test results value. In Table 3 there is a difference in the value of the test results pre-test and post-test control group. The pre-test and posttest result of the difference between experimental and control group show that there is a difference between the treatment groups with t value at 37.22; a significance level at 0.000, and sig 0.000 < 0.05. Furthermore, the independence of scientific work of student teacher of science was measured in the application of SIL model.



**Figure 2.** The Independence of Scientific Work of Student Teacher of Science Student on Ethnoscience Learning

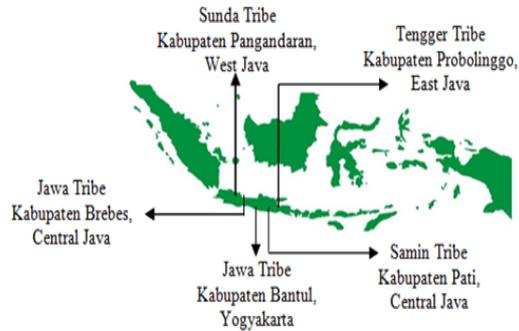
Description:

- A = Problem statement formulation
- B = Hypothesis statement formulation
- C = Develop the practical worksheets
- D = Instrument preparation
- E = Material preparation
- F = Practical work
- G = Report preparation
- H = Presentation
- I = Analysis of laboratory work results by integrating the data and facts
- J = Analysis of laboratory work results by integrating with the latest findings in the journal
- K = Communicating

According to Figure 2, the independence of the scientific work was in a very high category. Based on the analysis of 11 aspects of the independence of scientific work, there were 81 students who obtained very high category and 7 students showed high category. The independence of scientific work of students in this study resulted as the effect of the SIL model application. The test results of SIL model effectiveness on the independence of scientific work showed t value at 4.419 with significance at 0.000 and sig 0.000 < 0.05 as shown in Table 4.

This result represents that SIL model application was effective to improve the independence of scientific work of student teacher of science

students. Also, the results reveal that the students' independence work has transformed the indigenous knowledge to be scientific knowledge. The exploration of the indigenous knowledge was performed in 5 tribes in Java Island as shown in Figure 3.



**Figure 3.** Map Location of Indigenous Knowledge Exploration in Java Island

Some of the indigenous knowledge of the community has already proved scientifically in the laboratory experiment. Some examples of the experimental results are presented in Table 5. The student teachers of science are capable of changing the indigenous knowledge of the communities through experiments. The experimental results show that the tradition of the community in 5 tribes in Java Island inherits from their ancestor habit. Based on the result in Table 5, the indigenous knowledge has shown the value of scientific knowledge. The students were also asked to fill in the questionnaire after learning the Ethnoscience subject with the application of SIL model. The results of students' response are shown in Table 6.

Ethnoscience means of science knowledge owned by a nation or more precisely, a tribe or a particular of the ethnic group. Ethnoscience is given to student teachers of science to integrate indigenous knowledge as an integral part of the science learning. According to Wang & David (2002), the quality of human dignity is achieved through an appreciation of the potentials that exist in the environment.

**Table 4.** The effectiveness of SIL model on the independence of scientific work of students

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1(Constant)	22.904	4.196		5.459	.000
The effectivity of SIL model	.254	.057	.432	4.419	.000

**Table 5.** The Indigenous Knowledge of Communities in 5 Tribes of Java Island which are Transformed to The Scientific Knowledge through Laboratory Experiment

Tribe	Indigenous Knowledge	Scientific knowledge
Samin	Potion for exorcist blocker in Sawan disease.	The potion is made from 11 herbal ingredients. After laboratory examination, the herbs are containing saponin which serves as a medication.
Jawa	The production of salty egg in Brebes using brick dust and ash.	Brick dust and ash were proved to be the medium of salt bonding into the egg shell.
	Solanum leaves for sore throat medication in Bantul.	The color changing of the leaf extract after HCl and NaOH addition shows the flavonoid compounds.
Tengger	Putting the red onion on the infants' bed.	Red onion has alliin and allicin that neutralize the toxic compounds.
Sunda	The mixture of curcumin, salt, fish skin, and whiting to cure diarrhea.	Essential oil and curcumin, mineral and salt can substitute mineral loss of body during diarrhea condition.
	Coconut water for reducing the menstrual dysmenorrhea.	Coconut water contains electrolytes such as potassium and sodium which are useful to prevent dehydration caused by blood loss during menstruation.
Madura	Lime water for acne removal.	Lemon extract is known to contain essential oils to eliminate <i>Staphylococcus aureus</i> bacteria that cause infections, especially skin infections such as acne.
	Betel leaves to stop nose bleeding.	Betel leaf contains saponin that can stop the bleeding of the nose (nosebleeds).

Indigenous knowledge is part of the cultural life or society that is still maintained and believed to be true. The tradition is maintained because the people believed in the truth of genuine knowledge. Indigenous knowledge that has been converted into a science or science can enrich teaching materials (Wang & David, 2002; Lee et al., 2012; Kidman et al., 2013; Dwianto et al., 2017).

In the context of Ethnoscience as part of science learning, the learning materials and learning procedure have to be organized into a meaningful sequence in sections depending on the depth and difficulty level (Kabba, 2009; Hewitt

et al., 2013; Topaloglu & Kiyici, 2015). Science learning is oriented to the development of caring and responsible attitude towards the social and natural environment (Kabba, 2009; Hewitt et al., 2013). In learning, the material acts as the relationship among separated data sources (Morrison et al., 2007; Adam & Carl, 2010; Azarpira, 2012). There are two main characteristics in providing learning materials to help students acquire scientific literacy, i.e. the organization of the main ideas and clear integration (Silberman, 2006; Gregory, 2007; Trefil & Hazen, 2007; Widowati et al., 2017).

**Table 6.** Students' Response after Ethnoscience Learning by SIL Model Application

Statement	Average	Category
Learning materials are in accordance with the basic competencies	3.2	High
Learning materials of Ethnoscience are interesting	3.3	Very high
Learning materials of Ethnoscience encourage the testing of indigenous knowledge into scientific knowledge	3.7	Very high
Indigenous knowledge exploration activities stimulate the problem statement	3.2	High
Students are able to create the laboratory practicum worksheet independently	3.1	High
Students need to prepare the tools and experimental materials independently according to worksheet	3.1	High
The collection of lab results data is an integration between data and facts which are collected objectively	3.3	Very high
The problem is easily solved by analyzing the practical results which have been obtained by integrating data, facts, theories and findings of the latest issue from the scientific journal	3.3	Very high

Learning science aims to understand the history and culture of scientific developments and the evolution of knowledge along with its discipline (NSTA, 2003; Osborn, 2003; Tosun & Taskesenligil, 2011). Indigenous knowledge is a part of the original culture in the community which the source that can be obtained directly by observation, textbook, printed and electronic media. Disclosure of genuine knowledge society is done by applying scientific investigation to avoid mythical beliefs into science learning. According to Hsu et al. (2009), scientific inquiry is an authentic experience that shows the active involvement and has similarities with that done by scientists.

The average score of 8 items of the question after Ethnoscience learning by SIL model application is 3.28. This score represents the very high capability of students the implementation SIL model in Ethnoscience learning. SIL model is proved to be effective to improve the ability of students in integrating data, facts, and theories to transform the indigenous knowledge into scientific knowledge, especially in Ethnoscience subject. In general, SIL model has six stages of learning, namely; exploration, concepts integration, experimentation, analysis, action and reflection. In exploration stage, the students explore the information of indigenous knowledge in the community by observation, reading in printed and electronic media. The obtained information is briefly described. Students formulate problems and establish hypotheses for a further test through scientific work. Next, concept integration stage which maps the results of the exploration stage was performed.

Then, continue by the experiment stage which involves the student to prepare the practicum worksheet independently. In this stage, the students conduct the experiment in the laboratory. Phase experiment, experiment plan was drawn up independently in the form of worksheets practicum. Students prepare and conduct experiments. After experiment, the analysis stage was performed by integrating data, facts, theories, the recent findings (journal). After that, the action stage brings the student to draw the solution to solve the problems. Finally, the reflection stage is performed to let the students express their experiences from the exploration to reflection of learning activities into a reflective journal.

In fact, a pre-test result of the students on their Ethnoscience knowledge shows the low category of prior knowledge. In particular, students do not understand the methods to explore indigenous knowledge in the community, the concept of the knowledge and how to transform into a

scientific knowledge. In this study, the learning materials of Ethnoscience were delivered in the form of a soft file and hand out. Also, the materials learning activity applied SIL model in order to improve the students' understanding. By using this handout, the students can study everywhere and prepare themselves before learning in the classroom.

The learning material given to students has also been validated by the science teaching evaluation expert who has the record in the development of Ethnoscience learning material. According to the students, the Ethnoscience learning materials encouraged them to test the transformation of indigenous knowledge into scientific knowledge. In accordance with the opinion of Gondwe & Nancy (2014) and Meyer & Crawford (2011) who stated that learning materials with the integration of indigenous knowledge in it, can affect the students to learn science.

Moreover, SIL model application could lead the independence of the student in scientific work. Independence is a standalone, self-learning, independent, and initiative in learning and behavior do not cleave to another person, is required to have its own activity and initiative in learning and behavior (Depdiknas, 2008; Tahar & Enceng, 2006; Munthe, 2009). Learning independence is an attitude leads to awareness of own learning and consideration related to independent in learning activity and process. The higher education learning design is based on four assumptions, namely; the concept of independence to regulate themselves, the experience of adults is the repertoire, readiness to learn, and learn life-centered orientation (Pannen et al. 2001; Malcolm in Munthe, 2009).

By the application of SIL model, the students have explored the community's indigenous knowledge by the observations and analysis of information in printed and electronic media. In addition, the students of prospective science teachers are also able to formulate the problem and determine a hypothesis. The experiment plan is independently arranged in the form of practicum worksheets. Also, students have analyzed the results of the experiment by integrating data, facts, theories and recent findings (journal). Meanwhile, the follow-up of the original testing of indigenous knowledge organized in the form design and preparation of science learning materials. In fact, an independent experience of scientific work is effective after the application of SIL model. It is proved by coefficient t-test result with a significance value at  $0.000 < 0.05$  means that SIL model leads to the independence of prospec-

tive teachers in scientific work. This result is in accordance with the result of the study by Crone (2011); Novi & Parmin (2012) and Hewitt et al. (2013). The independence in direct experience effects on strengthens the students to accept, store, and apply the concepts they have learned.

The result of this study proved that student teacher of science is capable of changing the indigenous knowledge of five tribes in Java Island. The laboratory experiment to test the validity of indigenous knowledge was performed in the integrated science laboratories of three different universities. After the laboratory experiment, the obtained results show that the indigenous knowledge is scientifically proved and is now used by modern society as the product of technology. The experimental results are in accordance with the opinion of Cimer (2007); Schonborn & Bogeholz (2009). They stated that the indigenous knowledge of local communities has the scientific secret that can be verified through the application of scientific methods. By the stages of learning experiments conducted by student teacher of science insist that the traditional experiment conducted by tribe, ethnic, or traditional communities have the scientific truth.

## CONCLUSION

Science Integrated Learning (SIL) model affect the independence of scientific work in student teachers of science. The students have the independence of scientific work by showing their ability in planning, performing, concluding and communicating the experiment with its results in Ethnoscience learning. This study confirms that ethnic and cultural diversity has the potential of great scientific knowledge to be explored to enrich the learning resources.

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## ENHANCEMENT OF SCIENCE STUDENTS' PROCESS SKILLS THROUGH IMPLEMENTATION OF GREEN LEARNING METHOD (GeLeM) WITH CONSERVATION-BASED INQUIRY APPROACH

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### ABSTRACT

The inquiry of science teaching aims to encourage the ability to think, work and be scientific and communicate as an important aspect of life skills. Inquiry learning with Green Learning Method (GeLeM) focuses on the ability to think, work and be scientific. The data collection was conducted in the Department of Integrated Science, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Negeri Semarang on the course of General Biology, even semester of the academic year 2016/2017. The results show that application of method "GeLeM" can increase the average of cognitive value, learning response and the ability of students' Science Process Skill (SPS) in science learning especially biology in the material of the diversity of living creatures. Common biology lectures that use the method of Green Learning Method (GeLeM) can be collaborated with instilling conservation horizon on the students. The conclusion of this study is that Green Learning Method (GeLeM) can improve student cognitive result and science process skill in science learning. In addition, students are also able to find the concept that comes from the environment (nature), students can also love and care for the environment as a vehicle for learning.

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**Keywords:** Science Process Skill (SPS); Green Learning Method (GeLeM); inquiry; conservation

### INTRODUCTION

Science Learning (Science) has an important position in the development of the character of society and nation due to the progress of science which is growing very rapidly, the position of science that can be transferred in other fields, as well as science which contained the content of values and attitudes on which the formation of human character (Widowati, 2017). The process of learning science should include three aspects that must be obtained by students, namely the skills of cognitive thinking (minds on), psychomotor skills (hands on), and social skills (hearts on).

Science learning provides an opportunity to describe objects and events, ask questions, gain knowledge, and construct explanations of natural phenomena, test explanations of natural phenomena, test explanations in various ways and communicate them to others (Wahyuni, et al., 2017). Thus, knowledge of science is obtained through a process using scientific methods and provides opportunities for learning experiences, for example through reading, discussion, experimenting, making a summary and observing natural phenomena (Ngabekti, et al., 2017). Knowledge of science is obtained through a process using scientific methods. It provides an opportunity to gain learning experience through reading, discussion, experimenting, making a summary, and observing natural phenomena (Sayekti et al., 2012).

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Inquiry learning is one effective learning approach that can help students improve thinking skills by using higher mental processes and critical thinking skills (Astuti et al., 2013). According Yuniyanti et al., (2012), inquiry learning aims to provide a way for students to build intellectual skills (thinking skills) related to reflective thinking processes. If thinking is the main goal of education, then there must be ways to help individuals to build that ability.

The inquiry learning stages are identifying and asking questions, designing and conducting experiments, analyzing data and evidence, explaining and delivering the findings. This is in harmony with the skills that form the foundation for applying the scientific method or otherwise known as the science process skill. In addition to emphasizing the process of discovery (inquiry), science learning will also be more meaningful if it is done without overriding the principles of conservation so that it can form a character that cares about the environment and local culture (conservation). It is intended that the learning from the environment is still running and the environment can be well maintained. Learning by using inquiry approach according to Towndrow et al., (2008) is part of science.

According Trianto (2007) inquiry strategy means a series of learning activities that involve maximally all the ability to search and investigate the systematic, critical, logical, and analysis so that it can formulate their own concept of the discovery with full confidence. The main targets of inquiry learning activities are (1) maximal student involvement in the learning process; (2) logical and systematic activity harassment on learning objectives; (3) developing students' self-confidence about what is found in the inquiry process.

According to Putra (2013) inquiry can be grouped into 3, namely: guided inquiry Approach, free inquiry, and free modified inquiry. All inquiry activities involve process skills that include basic process skills, measurement and calculation skills, experimental planning skills, and the skills of processing and presenting data (Nur, 2011). Learning by inquiry method in the laboratory is also very effective in developing the skills of students' science process schools (Khan & Iqbal, 2011).

Green Learning refers to the Green Teacher learning model that has been coined and adopted from the term green teacher which was launched on February 28th, 2009 with the support of the Ministry of Environment. By referring to the operational explanation of the green

teacher, the concept of operational expression of green learning in the concept of college learning is (a) to give students the opportunity to develop a personal relationship with nature to provide student more knowledge as a teacher candidate; (b) to emphasize the relationship with other people or species; (c) future-oriented; (d) proficient use of mass media (ICT); (e) to include traditional knowledge and local wisdom; (f) to integrate several related disciplines; (g) awareness in learning in nature; (h) to utilize natural resources as a source of learning (Ardhi et al., 2014)

The use of GeLeM method can build cognitive aspect through concept discovery activity. The affective aspect can be built through cooperation activities among students at the time of learning, while in psychomotor aspects; inquiry learning is able to grow students' skills in working scientifically. Scientific work skills are undertaken by students in science learning, especially in general biology courses. These skills referred to science process skills (Ardhi et al., 2014).

Scientific process skills can be interpreted as an insight into the development of intellectual, social, and physical skills that come from the fundamental ability that already exists. Scientific process skills provide a proper understanding of the nature of science and can experience the stimulus of knowledge (Dimiyati & Mudjiono, 2009). According to Wibowo et al. (2013), process skill is a teaching-learning approach that leads to the development of fundamental mental, physical and social abilities as a driver of higher abilities within an individual. The process skill approach emphasizes the growth and development of certain skills in an individual so that they are able to process the information to discover new and useful things in the form of facts, concepts and the development of attitudes and values. Scientific process skills according to Yulianti & Wiyanto, (2009) is the ability or ability to carry out an action in learning science so as to produce concepts, theories, principles, laws, or facts or evidence.

Yulianti & Wiyanto (2009) divide the process skills into basic science process skills and integrated science process skills. According to Dewi (2008), basic science process skills consist of six skills, namely observation skills, classification skills, communication skills, measurement skills, prediction skills, and inference skills.

There has been a lot of research done by using natural media around, but the method of Green Learning is a method of learning in nature that uses natural media in learning as well as invites students to recognize and analyze environmental problems used as learning resources. The

objective of this research is to know the improvement of science process skill and the improvement of cognitive learning result of IPA students as implementation of Green Learning Method (GeLeM) with conservation-based inquiry approach.

## METHODS

This research is a classroom action research, conducted in accordance with student lecture schedule to obtain optimal results through the most effective way and procedure. This research is defined as one form of research that is reflective with the reasons to perform certain actions in order to improve the quality of learning in the classroom.

Data collection was conducted at Integrated Science Department, Faculty of Mathematics and Natural Sciences (FMIPA) Universitas Negeri Semarang in the subject General Biology course, even semester of the academic year 2016/2017. Population in this research is all students of even semester in Integrated Science Department of FMIPA UNNES who take general biology course in the even semester of the academic year 2016/2017. The research subjects consist of 68 students who are divided into group 1

and group 2. Samples are taken by using purposive sampling technique. The chosen subjects were students from group 2 consisting of 34 students.

The implementation stage of this research consists of several stages, namely observation, reflection and evaluation. Qualitative data were analyzed using flow method. The paths in the qualitative data analysis include: data reduction, data presentation and conclusion (Sugiyono, 2013).

## RESULTS AND DISCUSSIONS

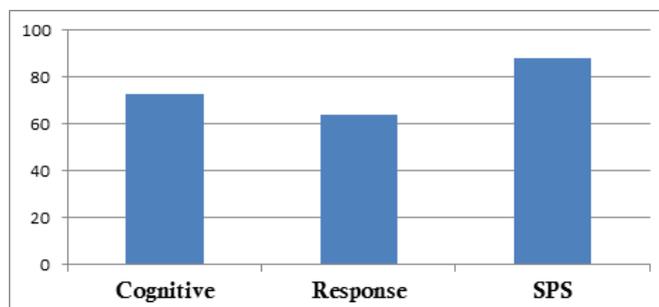
Classroom action research was carried out for 3 cycles through the implementation of 1 time face to face which is a cycle of action learning. Any findings obtained during each cycle during specific learning activities will be observed in the aspects of cognitive assessment, learning response questionnaire, and observation of SPS capability in each student in an experimental class.

### Pre-Cycle Stage

Learning activities at the pre-cycle stage were conducted using discussion and question and answer method without using "Green Learning Method". The result of the students' evaluation at the pre cycle stage can be seen in Table 1.

**Table 1.** Score Distribution of Pre-Cycle Stage

Cognitive			Response			PPP		
Int.	Frek.	%	Int.	Frek.	%	Int.	Frek.	%
58-62	2	5,9	34-43	2	5,88	79-81	1	2,94
63-67	3	8,8	44-53	5	14,71	82-84	0	0,00
68-72	9	26,5	54-63	6	17,65	85-87	16	47,06
73-77	14	41,2	64-73	16	47,06	88-90	10	29,41
78-82	4	11,8	74-83	3	8,82	91-93	4	11,76
83-87	2	5,9	84-93	2	5,88	94-96	3	8,82



**Figure 1.** Class Average Score in the Pre-Cycle Stage

The results of the pre-cycle learning achievement in Figure 1 show that the achievement of cognitive values is mostly obtained by the students at the interval of 73-77 and many others are in the 68-72 intervals. This shows the need to improve the quality of learning to improve student learning outcomes, one of which is done by using the method of learning "Green Learning" (GeLeM) which is implemented in several cycles to get quality learning outcomes.

Learning outcomes to be achieved in this study is that most students get a minimum value of AB (interval value 81-85). In addition to cognitive results, observations of learning responses are also conducted. The following is the result of students' learning response on achievement in pre cycle stage.

The condition of the learning response on the pre cycle of value dominance is at 64-73 value intervals. The circumstances indicate that the learning can still be improved in order to increase student responses to learning. Efforts are made by applying the learning method "GeLeM".

With this method, it is expected that there will be an increase in student cognitive outcomes as well as a good response at the time of learning (students are interested in attending lectures). In addition to cognitive results, the students' science process skill (SPS) is also assessed.

The value of SPS in the pre cycle stage indicates that the most value group is at the 85-87 value interval. However, the distribution of the values is not evenly distributed. There are still students who are at interval 79-81 so it is still possible to increase the student's SPS.

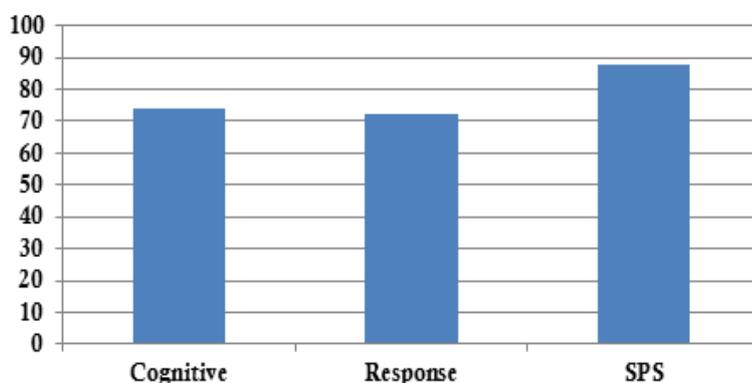
### Cycle 1 Stage

In the learning activity of cycle 1, the material of Protista was held in 1 meeting. In accordance with the planning in RPS, learning activities has been implemented by applying the Green Learning Method using observation methods and surrounding environmental media. At Protista's learning, students took samples from the environment to be observed using a microscope. Samples are taken from the surrounding environment in the form of wetland water and potential river water containing species from Kingdom Protista to be observed.

At the time of sampling, students are invited to observe the environment and analyze the environment. If the students observed the environmental problem, then they were immediately asked to discuss to solve the problem. Then the results of observations under the microscope were drawn on the worksheet that has been provided. The result of recapitulation of student achievement in cycle 1 can be seen in Table 2.

**Table 1.** Distribution of Students' Scores in the First Cycle

Cognitive			Response			SPS		
Int.	Frek.	%	Int.	Frek.	%	Int.	Frek.	%
59-64	7	20,6	54-59	2	5,88	82-83	6	17,65
65-70	5	14,7	60-65	3	8,82	84-85	3	8,82
71-76	7	20,6	66-71	10	29,41	86-87	4	11,76
77-82	9	26,5	72-77	12	35,29	88-89	7	20,59
83-88	5	14,7	78-83	5	14,71	90-91	6	17,65
89-94	1	2,9	84-89	2	5,88	92-93	8	23,53



**Figure 2.** Class Average Scores in the First Cycle

In learning activity of cycle 1, achievement of cognitive value is in value group with value limit above 77 equal to 44,1%, while value limit below 76 equal to 55.9%. The condition has not shown any significant improvement from pre-cycle. This can happen because students are still in adjustment to the application of learning with the method "GeLeM". Learning atmosphere in the first cycle of the first time applied method "GeLeM", so generally, there is a decline in scores of pre-cycle that has not applied method "GeLeM".

For class average score, cycle 1 achieved 74 which indicates a slight increase from pre-cycle average of 73. This is because in the interval group, the scores above 77 increase in terms the the number of frequencies. In addition to cognitive assessment, assessment of learning responses is also performed. It aims to determine the student's response to the learning that was conducted with Green Learning Method. Based on the learning response, the dominant scores of the 1st cycle is at intervals of 72-77 with a percentage of 35.29%. There is an increase of pre-cycle dominant scores in the 64-73 score group with a percentage of 47.06%. The condition shows that the "GeLeM" method of learning is well received by students, compared to the practicum method and discussion without using "GeLeM" method.

The ability of SPS students in cycle 1 increased compared to pre-cycle, ie there was an increase in the number of students who had achieved the value of Skills Process of Science (SPS) above 90, the condition indicates a positive relationship between "GeLeM" learning method and the skill that is mastered by students during practicum activities.

## Cycle 2

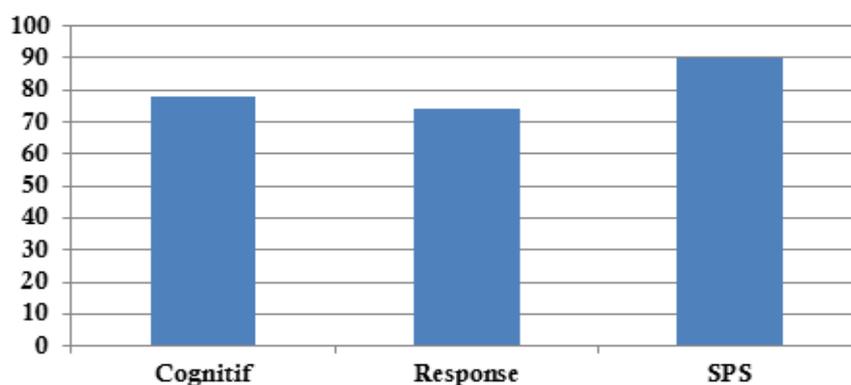
The learning activity of cycle 2 about Plantae material was held in 1 meeting. In accordance with the planning in RPS, the meeting has

implemented learning activities by applying the Green Learning Method using observation methods and surrounding environmental media. In learning Plantae, students observe the diversity of plants that exist in the environment around the campus in this case the Faculty of Mathematics and Natural Sciences. After observation, the students draw the observed plant species and give the organ's information on the plant species. At the time of observation, the students also observed the surrounding environment, analyzed the environmental problems found and collected waste at the time of observation. It aims to make students more concerned about the cleanliness of the surrounding environment. In addition, the students also separated the organic and non-organic waste found. The result of recapitulation of student achievement in cycle 2 can be seen in Table 3.

In learning activity of cycle 2, achievement of cognitive score is in score group with scores above 78 equal to 58,8%, while score limit below 77 equal to 41.2%. These conditions have shown a significant increase of the cycle. This means that the students are getting used to using the "GeLeM" method and the value interval also shows that the "GeLeM" method is able to improve students' cognitive value in understanding the material of the diversity of living creatures especially on Kingdom Plantae material. The class average score in cycle 1 reached 74 while in cycle 2 reached 78. Based on the learning response in cycle 2, the dominant value was in the interval group of 71-79 with the percentage of 44.12, an increase from cycle 1 which dominant score was in the interval of 72-77 with percentage of 35.29%. The situation shows that the learning method "GeLeM" can be well received on the students, and influential both in learning. Good response from students shows that students interested in understanding the material by using "GeLeM" learning method.

**Table 3.** Distribution of student scores of cycle 2

Cognitif			Response			SPS		
Int.	Frek.	%	Int.	Frek.	%	Int.	Frek.	%
63-67	2	5,9	44-52	1	2,94	79-81	1	2,94
68-72	3	8,8	53-61	6	17,65	82-84	0	0,00
73-77	9	26,5	62-70	3	8,82	85-87	3	8,82
78-82	13	38,2	71-79	15	44,12	88-90	10	29,41
83-87	4	11,8	80-88	5	14,71	91-93	13	38,24
88-92	3	8,8	90-98	4	11,76	94-96	7	20,59



**Figure 3.** Class Average Scores of Cycle 2

The method can be applied well to improve students cognitive ability. The ability of SPS of students in cycle 2 increased compared to cycle 1, that is an increase of the number of students who succeeded in achieving the value of Science Processing Skills (SPS)  $\geq 90$ . In cycle 1, the group score  $\geq 90$  was 41.18% while in cycle 2 was 58, 83%. The condition indicates a positive correlation between "GeLeM" method of learning method and the science skill that is controlled by the students during the learning activity with "GeLeM" method.

Application of the "GeLeM" method can spur the increase of SPS to the students. The results of cognitive learning and the ability of the student science process obtained up to cycle 2 have increased significantly. However, it is necessary to carry out the next cycle to find out the continuity of the action, so it can be assured that learning by applying the "GeLeM" method can still improve the cognitive and SPS scores in the next lesson.

### Cycle 3

The activity of learning cycle 3 about the material Animalia was held in 1 meeting. In ac-

cordance with the planning in RPS, the meeting implemented learning activities by applying the Green Learning Method using observation methods and surrounding environmental media. In Animalia learning, students observed the diversity of animalia present in forests and beaches. After observation, students draw animals observed and give information to the organ of the animal species. At the time of observation, the students also observed the surrounding environment, analyzed the environmental problems found and collected waste at the time of observation. Here is a recapitulation of student cognitive achievement in cycle 3. The result of recapitulation of student achievement in cycle 3 can be seen in Table 4.

Learning activity in cycle 3 achieved cognitive scores above 78 equal to 85,3%, while scores below 77 equal to 58,8%. These conditions have shown a significant increase of the cycle. This means that the students are getting used to using the "GeLeM" method and the score interval also shows that the "GeLeM" method is able to improve students' cognitive value in understanding the material of the diversity of living creatures especially on Kingdom Plantae material.

**Table 4.** Student Score Distribution of Cycle 3

Cognitive			Response			SPS		
Int.	Frek.	%	Int.	Frek.	%	Int.	Frek.	%
74-77	5	14,7	79-82	4	11,76	84-85	1	2,94
78-81	9	26,5	83-86	10	29,41	86-87	0	0,00
82-85	8	23,5	87-90	13	38,24	88-89	1	2,94
86-89	6	17,6	91-94	4	11,76	90-91	6	17,65
90-93	4	11,8	95-98	2	5,88	92-93	10	29,41
94-97	2	5,9	99-100	1	2,94	94-95	16	47,06

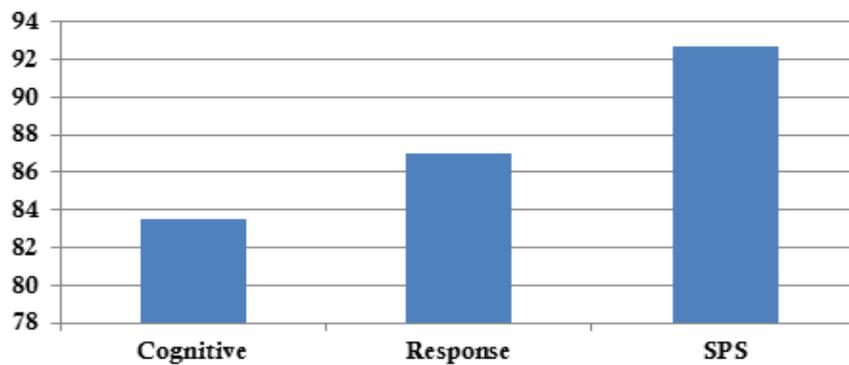


Figure 4. Class Average Value of Cycle 3

The class average score in cycle 1 reached 74 while in cycle 2 reached 78. This shows a significant increase of the average value of the class. During the learning activities, assessment of the learning response is still carried out.

The dominant score based on learning responses in cycle 3 is in the interval group score of 87-90 with the percentage of 38.24% which increase from cycle 2 which dominant score is in the interval group score of 71-79 with the percentage of 44.12%. The condition shows that the learning method "GeLeM" can still be well received on the students, and it became good influence in learning.

The student's SPS capability in cycle 3 increased compared to cycle 1, which is the increase of the number of students who achieved the value of Science Skills Processing (SPS)  $\geq 90$ . In cycle 2, the group value of  $\geq 90$  is 58.83% while in cycle 3 is 94, 12%. the condition indicates a positive correlation between "GeLeM" learning method and the science skill that is controlled by the students during the learning activity with "GeLeM" method. This means that the more frequently applied the method, the more the students are trained in observation and other science activities. It improved students' science process skills to become better. The results of cognitive learning and the ability of the student science process obtained up to cycle 3 have increased constantly and significantly so that the cycle can be stopped.

Learning by applying the method "GeLeM" can increase the cognitive and SPS values in science learning, especially biology in the material of diversity of living things.

## CONCLUSION

The concept of operational elaboration of Green Learning Method (GeLeM) in the concept of learning in universities is to give students

opportunities to develop personal relationships with nature as an aspect that a teacher candidate should have. This concept also emphasized relationships with other people or species and activities of human beings on the planet, helped students move from a "direct-to-face" to futuristic-oriented, helped improve them in using mass media and (ICT) experience, included traditional knowledge and local wisdom, integrated multiple related disciplines, fostered consciousness in learning nature, as well as utilized natural resources as a source of learning.

Common biology lectures that use the method of Green Learning Method (GeLeM) can be collaborated with the planting of conservation insights on the students. In this study, the students are able to find the concept that comes from the environment (nature), students can also love and care for the environment as a vehicle for learning. Learning by applying the "GeLeM" method can improve the average of cognitive score, learning responsiveness and the ability of student SPSs in science learning especially biology in the material of diversity of living things.

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