



## DEVELOPING SCIENCE LEARNING MATERIAL WITH AUTHENTIC INQUIRY LEARNING APPROACH TO IMPROVE PROBLEM SOLVING AND SCIENTIFIC ATTITUDE

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### ABSTRACT

This research was conducted to (1) produce science material learning based Authentic Inquiry Learning which is appropriate to improve problem solving and students scientific attitude; (2) know the potency of developing scientific attitude in science learning material based authentic inquiry learning; and (3) know the potency of developing scientific attitude in science learning material based authentic inquiry learning. The research method was Research and Development (R & D), by pointing to Four D models and Borg & Gall Model. There were 4 main phases (define, design, develop, disseminate) and additional phases (preliminary field testing, main product revision, main field testing, and operational product revision). The instruments used included product validation questionnaire, problem solving test, observation sheet of problem solving, and scientific attitude questionnaire. Result data of validation, problem solving test, scientific attitude questionnaire were analyzed descriptively. The result showed that : (1) science learning material based authentic inquiry learning that was developed was considered as very good by expert lecturers and teachers, and it was appropriate to use in learning process; (2) science learning material based authentic inquiry learning could improve students' problem solving; (3) science learning material based authentic inquiry learning could improve students' scientific attitude.

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**Keywords:** learning material; authentic inquiry learning

### INTRODUCTION

Indonesia has to be ready to face a global challenge in this 21st century. The demands include students that need a mind, verbal and written communication, team work, creativity, research skill, and problem solving to compete and grow well in the future. However, education environment does not facilitate to teach those skills to students. Students are clever on text, but poor in applying. Students are less at socializing in real life, strange with learning context to the real life and strange towards the conceptualization process, so they claim science as pure theory. Students do not understand the benefit and

the meaning of why they learn science. Besides, they often succeed in solving a simple problem, but they face difficulty even failure if the problem context changes little. Indeed, as what was stated by Setyawan that someone was tended to use his cognitive creatively, by continuously modifying and using the concept to compromise with daily problems (Kurniawan, 2013).

Heuvelen (Wijayanto, 2011) presented result survey done by American Institute of Physics in the United States that the most commonly used competence for workers were competence in problem solving, team work, and communication. As the resulting survey done by Council Science and Technology in British showed that about 30% workers used science in some of their working aspects and problem-solving skill was

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always needed in many occupation or expertise. But a research done by Organization for Economic Cooperation and Development (OECD)-as international research organization- showed that education in Indonesia placed the second lowest after Tunisia in problem solving competence and third lowest after Brazil for science competence. This result was saddening. The reasons could be suggestions how human resource in Indonesia should be developed through education, especially in science.

Osborne & Collins stated that most students like to work at laboratory by cook book type, which presents detail steps one by one. It is what makes laboratory activity becomes boring, and it does not relate to real life (Koretsky *et. al.*, 2012). Duschl & Bybee (2014) also added that science learning by *doing in Science* could improve students knowledge about science and how dynamically science was produced, competed, and repaired. Surly to make this kind of learning, teachers have to face a big challenge and responsibility to support students to learn to improve their understanding and skill to face real life.

Based on the explanation above, a social skill like problem solving is important to be oriented in science learning. Attitude aspect is also one of those that cannot be ignored in science learning, and it is necessary to be created in students mind so that they become a superior human resource, enable to conform intellectual, emotional, and spiritual aspects, enable to improve many intellectual potencies they have optimally and equally.

Teachers could put scientific attitude through research activity done by students, either experiment or exploration. Teachers are aware that scientific attitude is important, but it gets less attention for the purpose of learning. It makes scientific attitude is often ignored because teachers also face difficulty in designing strategy or learning approach to improve scientific attitude and document result study of scientific attitude. However, as it was explained by Kaplan (Prokop *et al.*, 2011) that some researches had proven there was a positive relation between scientific attitude and students' cognitive result study. Kaplan also stated that "students achievement in science is, together with attitudes, the most important indicator, or predictor, of the science education outcome" (Prokop *et al.*, 2011).

Education, including quality of science education, is demanded to build good human resource. Besides, science learning also has a principle to create students become long life learner since education cannot be described as life

preparation, but it should be seen as the art of life itself. Fitriani *et al.* (2016) stated that "science learning in school could be applied by connecting the materials in the learning with real life." As a consequence, strategy or innovative learning approach are needed to make them real. Two innovative approaches are authentic learning and inquiry approach.

Authentic learning happens when the teacher provides a chance for students to learn and help them to inquire actively, solve the problem, and think critically and reflect problems in daily life. Inquiry approach teaches students how scientists work. This approach can motivate students to become thinker, curious, cooperative and problem solver. Based on this reference study, it needs urgently the combination of authentic learning and inquiry approach to making innovative learning that can support students inquiry towards world change. Teachers in science learning, with authentic inquiry approach, can teach their students to observe object and natural phenomena, by using society potency as a learning source, and become connectors between school and its environment. Besides, learning process should be emphasized on actual problems that are directly related to real life and useful for society life or contextual quality.

To teach students by using authentic inquiry learning needs learning the material. A complete learning material would help teachers in teaching, and students in learning process. A learning material ensures to reach the purpose of learning. A systematic learning material to train problem solving and scientific attitude is hard to find. Besides, books and students' science worksheet nowadays are rigid and boring for students, so they are less interested in science (Asa, 2011). Besides, published learning materials also pay less attention to students scientific attitude and tend to present science as a body of information, not research method. Based on these backgrounds, it is necessary to develop science learning material based on authentic inquiry learning in order to improve problem solving skill and scientific attitude.

Research questions in this study are: (a) how is the quality of science learning material based on authentic inquiry learning according to experts and teachers if it is seen from the material, graphic, presentment, and language aspects?; (b) can science learning material based on authentic inquiry learning approach improve problem solving skill?; (c) can science learning material based on authentic inquiry learning approach improve scientific attitude? The purposes of this study

are to know: (a) the quality of science learning material based on authentic inquiry learning approach seen from material, graphic, presentment, and language aspects; (b) the potency in improving problem solving skill by using science learning material based on authentic inquiry learning approach, (c) the potency in improving scientific attitude by using science learning material based on authentic inquiry learning approach.

## METHODS

Research methods used in this study referred to four D models and Borg & Gall. Development procedures consisted of 4 main phases (define, design, develop, and disseminate) and additional phases (preliminary field testing, main product revision, main field testing, and operational product revision) that were taken from Borg and Gall procedure. Define phase was a phase of collecting first data by literature review and field survey. In this phase, the writer analyzed local potency around the school, curriculum, learning condition, and students characteristics. The design phase was a phase of developing the first product by preliminary field testing, main product revision, main field testing, and operational revision.

Subjects in this study were students JHS grade VII and VIII in some schools in Yogyakarta. This study was done on May – November 2015. The instruments included:

1. Questionnaire of learning material validation used to get data about product review from experts and science teachers of JHS towards the developed learning material. This questionnaire included: material, language, presentment, graphic, and inclusiveness of authentic inquiry learning aspect, and inclusiveness of problem solving and scientific aspects.

2. Scientific attitude questionnaire was used to know the improvement of students' scientific attitude. The indicators of scientific attitude used were indicators developed by Harlen (2000).
3. The test was used to know the improvement of students' problem solving skill after doing learning process by using material based on authentic inquiry learning. Test instrument was arranged based on the indicators available in standard basic competence in materials adapted to students' problem solving indicators. Problem solving indicators included: (1) identifying problem; (2) formulating problem; (3) finding alternative solutions; (4) choosing the best solution; (5) fluency in solving the problem; and (6) quality of problem solving result. For problem solving skill, each item in the question was given maximum score 4, and the result of each aspect was converted into scale 5 category and counted its N-gain score.
5. Observation sheet was used to support improvement data of students' problem solving skill got from the test. The instruments were a questionnaire and observation sheets using Likert scale 1 to 4 score and the resulting score was counted its average in each aspect, then converted into scale 5 category.

## RESULTS AND DISCUSSION

Based on the result analysis of local school nature potency (all objects in the school yard and the environment around), we got a specific object for science learning with all problems for students. Then the result was synchronized with science material in the applied curriculum (Curriculum of unit level education & Curriculum 2013). The result of synchronization was in Table 1.

**Table 1.** Synchronization between local potency and JHS science curriculum

Specific Object	Scientific Problem Question	Material in Science Curriculum
River Code	Is the river polluted? What should effort be made to solve it?	Water Pollution
Food franchise outside school	Is the ingredients of food at school safe? How to detect and what effort should be made to keep the food ingredients safe for health?	Addictive Substances in Food
Mount Merapi, River	How do the objects around change?	Object Change
Hydrallic fish pool, big tree, group of hyacinth	How is the photosynthesis?	Photosynthesis
Crowded street	What is the effect of dirty air? How to minimize dirty air?	Air Pollution

Based on the analysis result of local school potency and curriculum, science material themes taken as a title in accordance with Curriculum of Unit Level Education were Addictive Substances in food, Protecting Our Earth from Air Pollution, Water for Life and themes in accordance with curriculum 2013 were: Objects Change around us, Photosynthesis.

Based on the analysis of students characteristics, the developed scientific attitudes were curiosity, respect towards facts and cared towards the environment. Learning material focused on developing problem solving skill and scientific attitude, because they were important things that should be developed as century 21 demands. It was also as preparation to face curriculum 2013 that explicitly stated main competence like skill and attitude. The developed learning materials were: Pocket Book and Addictive Substances in food, Protecting our earth from air pollution, water for life, e-module objects change around us.

The format of learning material or pocket book was as the following: (1) learning instruction; (2) Competence; (3) Supporting Information; (4) Exercises; (5) Worksheet Instruction; (6) Evaluation. The format of students worksheet was adapted from LKPD, such as (1) Activity Title; (2) Purposes; (3) Tool and Material; (4) Work Procedure; (5) Data Table; (6) Discussion Material. Learning material in this study was arranged based on authentic inquiry learning approach, it was the combination of guided inquiry and authentic learning. Inquiry approach was facilitated with paying attention to the steps in a worksheet like formulating the problem, formulating a hypothesis, collecting data, analyzing data, taking a conclusion, and generalizing. Authentic learning approach was characterized by the contextual problem, investigating activity to help improving students' thought, collaborating, students product, using various learning sources, and or reflecting.

### Validators' assessment toward the product of science learning material based on authentic inquiry learning approach

Validating science learning material with authentic inquiry learning approach was done by three expert lecturers and 3 teachers (practitioners). The result was on Table 2. Table 2 showed that science learning material that was developed by using authentic inquiry learning approach was considered as very good in most aspects (material, graphic, language, presentment). The suggestions and critics by validators towards science learning material based on authentic inquiry learning approach were:

1. Indicators and learning purpose did not reflect basic competences,
2. The purpose of "knowing" should be changed into appropriate verb for Inquiry and Problem Solving activities,
3. Concept emphasize in learning material in students' worksheet was not so good,
4. Local potency/ environment should be explained more detail,
5. Concept map should be revised because there were little mistakes and explained more clearly by using words descriptors,
6. Cognitive chain should be paid attention and adjusted with activity steps and discussion question in learning material,
7. It needed more reference especially in work procedures in students worksheets,
8. Term consistence should be paid more attention,
9. There were some sentences that did not fulfill language grammatical and Structural,
10. Punctuation should be rechecked,

The follow up of suggestion and critics above were done, and the product of learning material was repaired as the following:

1. Repairing indicators and purposes by adding materials loaded in basic competences,
2. Adding word "observe," "find," "suggest

**Table 2.** Lecturers and teachers validation towards science learning material based on authentic inquiry learning approach

Appropriateness	Lecturers		Teachers	
	Score	Category	Score	Category
Relevant requirement of material	3,64	Very Good	3,76	Very Good
Relevant requirement of language	3,53	Very Good	3,47	Very Good
Relevant requirement of presentment	3,73	Very Good	3,74	Very Good
Relevant requirement of graphic	3,71	Very Good	3,61	Very Good
Average	3,65	Very Good	3,65	Very Good



- idea or solution" as purposes,
3. Adding questions in discussion to make science learning material references wider,
  4. Emphasizing school local potency by presenting facts at the beginning of activity by looking at contextual and school local potency,
  5. Repairing concept map in learning material by checking the appropriateness of sub-concepts with main concepts and adding words descriptors,
  6. Evaluating activity that was appropriate with theme, checking question order so that it was relevant to cognitive chain,
  7. Giving instruction in students' worksheet so that they opened more references,
  8. Repairing punctuation with the correct language grammar and structure,
  9. Changing image in cover to be relevant with theme,
  10. Repairing display to be more simple but still interesting.

Science learning material based on authentic inquiry learning approach was developed and repaired based on the relevant suggestions. All lecturers and teachers had given assessment that developed science learning material had already used authentic inquiry learning approach including contextual problems were taken, inserting investigation with steps of inquiry approach (formulating problem, formulating hypothesis, testing hypothesis, analyzing data, taking conclusion, developing new problem), students had chance to collaborate, students produced something, using many learning sources, students reflecting. Besides, validators also stated that the developed science learning material loaded problem solving with indicators to identify and formulate the problem, give an alternative solution, and do the best solution.

Learning material product that was revised in accordance with validators suggestion and critics was tested to the subjects, students grade VII and VII of JHS. This test was done to know the potency of science learning material with authentic inquiry learning approach to improving problem solving and scientific attitude.

#### **Developing students' problem solving skill by using science learning material with authentic inquiry learning approach**

The test was done limited to students grade VII or VIII of JHS based on the materials given. Students' problem solving observation was done during learning process with science learning material with authentic inquiry learning approach,

problem solving test was given before (pretest) and after learning (post test) or only post test. The result of problem solving post test was as on Table 3.

**Table 3.** Students' problem solving post test result

Problem solving skill aspects	Average score	Category
Identifying problem	3,43	Very Good
Formulating (analyzing) problem	3,36	Very Good
Finding alternative solutions	3,08	Good
Choosing alternative solution (best)	3,05	Good
The fluency in solving problem	3,72	Very Good
The quality in problem solving result	3,34	Very Good
The average of problem solving skill	3,33	Very Good

Table 3 showed that most aspects of students' problem solving skill were very good based on the post test result. Finding and choosing alternative solution were categorized as good. The result of the N-gain score from problem solving skill tested twice as Table 4 showed.

**Table 4.** Pretest and post test result of problem solving

Problem solving skill aspects	Score	
	Pretest	Posttest
Identifying problem	1,91	3,55
Formulating (analyzing) problem	1,91	3,36
Finding alternative solutions	1,96	2,91
Choosing alternative solution (best)	1,85	2,90
The fluency in solving problem	1,99	3,86
The quality in problem solving result	1,88	3,38
The average of problem solving skill	1,92	3,33
N-Gain Score	0,68	
Category	Medium	

Table 4 showed that there was an enhancement on students' problem solving skill by using

science learning material with authentic inquiry learning approach. It was showed from N-gain score value which was 0,68 (medium category). In general, all aspects of students' problem solving skill improved. Besides using test, students' problem solving during learning process with science learning material based on authentic inquiry learning approach were observed per each meeting.

**Table 5.** The result of students' problem skill observation

Problem solving skill aspects	Meeting no-		
	1	2	3
Identifying problem	2,03	2,48	3,41
Formulating (analyzing) problem	2,40	2,64	3,27
Finding alternative solutions	2,45	2,47	3,30
Choosing alternative solution (best)	2,61	2,69	2,94
The fluency in solving problem	2,09	3,01	3,23
The quality in problem solving result	2,78	2,58	3,26

Test result showed that problem solving skill could improve by using science learning material based on authentic inquiry learning approach. It was because either inquiry approach or authentic learning approach could improve problem solving skill. The inquiry could train high ability to think skill, including problem solving skill for identifying the problem, formulating the problem, and finding alternative solution aspects. Inquiry approach could facilitate students to think higher to develop a process in understanding principle and concept (Friedel *et.al.*, 2008:72). Pratt and Hackett added that "... teaching science by inquiry involves teaching students science process skill, critical thinking, scientific reasoning skill used by scientists (Ergul *et. al.*, 2011). Inquiry based learning could improve intellectual and creativity through thinking process (Lawson, 2010), develop science literal, knowledge, concept understanding, scientific attitude (Anderson, 2002), critical thinking, process skill (Anderson, 2002; Panasan & Nuangchalem, 2010). Sukma & Ibrahim (2016) stated that "Teaching and materials for active learning of guided inquiry-integrated bowling campus are proved to be able to increase learning outcome of Junior High School student". The research result of Hairida (2016) showed that inquiry based module with authentic

assessment in addictive substances material was effective to improve students inquiry skill and critical thinking, N-gain score of experiment class was higher than control class.

Lombardi (2007) stated that authentic learning was focused on complex problems that might be faced in real life and solution of that problem, that would create a condition which demands students to be able to improve their high analyzing skill and communication. Authentic learning also facilitate students to solve the problem with many alternative solutions. Emphasized by Harris & Rooks (2010) that recent education research result shows new perspectives which are appropriate to use in science learning and apply in science activities related to daily life (contextual). It made students think about problems in life (contextual) and apply their science knowledge so that they used their ideas, tried to understand deeper as well as their knowledge on ho to observe in science. In this case, students' science knowledge could improve when they were given a chance to participate observation activity to solve the contextual problem. So, the combination of authentic approach and inquiry, authentic inquiry learning, could possible improve all aspects of problem solving (identifying problem, formulating problem, finding alternative solutions, choosing alternative solutions, the fluency in solving problem, the quality in solving the problem).

#### **Developing scientific attitude by using science learning material based on authentic inquiry learning**

Based on the assessment by expert lecturers and teachers, the developed science learning material had potency to improve scientific attitude with details: (1) the score of curiosity reached 3,57 from lecturers and 3,87 from teachers; (2) the score of respect towards facts reached 3,67 from lecturers and 3 from teachers; (3) the score of care towards environment reached 4 from lecturers and teachers. The result was also emphasized with students questionnaire which showed science learning material with authentic inquiry learning approach as Table 6, 7 and 8 showed.

Table 6 showed that generally, students curiosity grew well. It means that science learning material with authentic inquiry learning approach could improve students' curiosity.

Table 7 showed all aspects of respect towards fact could improve well, even for objective aspect was categorized very good by using science learning material with authentic inquiry learning approach. It meant that science learning material with authentic inquiry learning approach could

**Table 6.** Questionnaire result of curiosity

Indicators of curiosity	Minimum average score	Average score	Category
Paying attention to new things	4	3,55	Very Good
Observing or trying to answer curiosity	4	3,40	Very Good
Enthusiastic to search the answer	4	3,49	Very Good
Looking for information spontaneously from book or other sources	4	3,14	Good
Formulating problem on science students' worksheet stimulates students' curiosity	4	3,36	Very Good
Rerata		3,39	Very Good

**Table 7.** Questionnaire result of respect towards facts

Indicators of respect towards facts	Maximal average score	Average score	Category
Objective	4	3,33	Very Good
Not manipulating data	4	3,12	Good
Rechecking the result	4	2,98	Good
Taking conclusion	4	3,06	Good
Admitting conclusion to be temporary	4	2,63	Good
Average score		3,02	Good

**Table 8.** questionnaire result of care towards environment

Indicators of care towards environment	Pretest		Posttest	
	Average score	Category	Average score	Category
Know and understand the indicators of care towards environment	2,81	Good	3,69	Very Good
Enable to give idea about care towards environment	2,82	Good	3,68	Very Good
Persuade students to care towards environment	2,67	Good	3,30	Very Good
Average	2,77	Good	3,57	Very Good
N-Gain score			0,65	
N-Gain score category			Medium	

improve students' respect towards fact.

Table 8 which there was an enhancing score and category in students care towards the environment. The score after post test was higher than pretest with N-gain score 0,65 (medium category). Three aspects of care towards environment were categorized very well after using science learning material. It meant that science learning material based on authentic inquiry learning could grow students' care towards the environment.

The questionnaire results of Table 6, 7 and 8 showed that science learning material based on authentic inquiry learning could grow or improve students' scientific attitude. It was because inqui-

ry could improve scientific attitude. Inquiry learning could sharpen process skill and understanding concept better, and also improve students' scientific attitude (Ergul et al., 2011 ; Viera et al., 2011) stated that teachers should believe that teaching with inquiry approach could stimulate students to study and it was not the pure process of transferring knowledge because world change becomes more complex, there might be many situations with no solution. Khusniati (2012) also stated that "learning which applied inquiry could improve many characteristics such as critical thinking, creative and innovative, curiosity, respect to others' opinion, polite, honest, and responsible."

Besides that, Lombardi (2007) said that authentic learning provided a learning process to students to reflect either individual or group, and could cause them adopt many roles and think from many views. Authentic learning could also enable affective skill (value, respect, and care) and conative skill (act, decide, and commitment) to improve (Lombardi, 2007).

Based on the reasons above, authentic inquiry learning indeed could improve students' scientific attitude. Learning with authentic inquiry learning approach could teach many attitudes needed in learning to improve scientific attitude as stated by Klausmeier & Goodwin (1971) that learning which could improve attitude needed to focus on problem, providing example of attitude, help students to arrange the goal of attitude, ask students to give reason towards their attitude, give feedback and correction, and emphasize.

Based on the result of this study it could be stated that learning with authentic inquiry learning approach could improve students' problem solving and scientific attitude, and also create meaningful science learning process. Reiter (2015) said that "Meaningful learning implies the active involvement of the learners/students in whatever is being taught. It is based on a holistic approach to the learners, calling for their cognitive, emotional and behavioral attention". (Drake (2014) also said that meaningful learning was not only active in thinking but also active in behavior and attitude. Authentic inquiry learning was a learning referring to the authentic scientific inquiry, where Schwartz & Crawford (2006) emphasized that "authenticity as it pertains to the practice of scientific inquiry, conducted by scientists, within the community of science." Learning could be said authentic if it was done by observing, worked by scientists, in community/ science environment. It meant that learning should bring problems in an environment which related to science and observe to solve the problem. Schwartz & Crawford (2006) also stated that the main difference between inquiry and authentic learning was in their meaning.

## CONCLUSION

Science learning material with authentic inquiry learning approach was considered to be very good, seen from material, presentment, graphic, and language aspects by lecturer and teacher, and it was appropriate to be used in learning process,

Science learning material with authentic inquiry learning approach could improve stu-

dents' problem solving skill,

Science learning material with authentic inquiry learning approach could improve students' scientific attitude.

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## DEVELOPING SCIENCE PROCESS SKILLS AND PROBLEM-SOLVING ABILITIES BASED ON OUTDOOR LEARNING IN JUNIOR HIGH SCHOOL

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### ABSTRACT

This research aims to develop science process skills and problem-solving abilities based on outdoor learning in junior high school. This study uses a mixed method design embedded experimental models. Data was performed in the qualitative and quantitative analysis. Qualitative data analysis is used to determine the science process skills while quantitative data analysis is used to determine the increasing problem-solving ability by using normalized gain (N gain) formula. The results show that the science process skills developed at every phase comprise of making observations, formulating hypotheses, experiment, create data, classify and analyze the data, formulating its conclusions, communicate, and apply the concepts and make predictions obtained by the average value of 75.33 in the good category. While the problem-solving ability of students based on outdoor learning also increased by 0.58 in the medium category. The conclusions of this research show that the application of outdoor learning can be teacher use as an alternative to learning, so it is quite effective in developing science process skills and problem-solving abilities.

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**Keywords:** science process skills; problem-solving abilities; outdoor learning

### INTRODUCTION

Natural Sciences (IPA) is a way to find out about nature systematically is not only mastering a set of knowledge but also finding process and knowledge reconstruct through scientific procedures as performed by the scientist. According to Wahyuni (2015), IPA is a set of knowledge about objects and natural phenomenon obtained from the result of thought and investigation conducted by skills of scientists experimented using scientific methods. Learning will be meaningful if the investigation activities and experiments involving students actively and directly related to learning resources.

Characteristics of IPA learning is a lear-

ning including product, process, scientific attitudes, and daily applications. The fourth element is a whole IPA characteristic and can not be separated from each other. The process of IPA learning should have a direct experience of students thereby increasing students ability to construct, to understand, and apply the concepts learned (Lisdiyawati, 2012). Thus, students will be practiced to find their various concepts holistically, meaningful, authentic and applicable to problem-solving. It corresponds in Ango (2002) which states that there are two kinds of options in the process of learning that is meaningful and rote learning.

Based on observations during the learning process in schools, to activate the students, teachers usually assign the task directly from the textbooks, worksheets or undertake LKS with the task to summarize material. Although the purpo-

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se is to activate students and reduce the lecture method, the main point is the targeted material can be completed. Though most students only use the level of the basic concepts that have been obtained previously in learning (MCBride et al., 2010). According to Sumarni et al. (2016), the criteria for good IPA learning not only from books, but teaching should include practice instrument as well as associated with the environment. Therefore developed IPA learning connecting or brings together the various fields into a single discussion. According to Solichah et al., (2013), IPA learning carried out in an integrated can improve learning achievement, process skills and attitudes of students towards science.

Science process skills are skills that need to be implanted, practiced and owned by students. It is the foundation for scientific inquiry and intellectual development necessary to learn the science concepts (Duran et al., 2011). According to Ergül et al., (2011) developing science process skills enable students to problem-solving, thinking critical, make decisions, looking for answers, helping students to logical thinking, ask questions in a reasonable and problem solving they face in daily.

Problem-solving is one of the very important ability in science learning (Heller et al., 1992, Afriana et al., 2016). Science issues are an idea that is important to build the capacity of students' problem solving and make science lessons more fun and motivate students to perform better. Problem-solving skills used in solving problems of science in mathematical form and solves the problem of phenomena happens in the environment. But in fact, students experiencing difficulties because of the strategies taught in learning only to solve problems that require mathematical calculations (Ogilvie, 2009).

One of the learning which utilizes nature as a source of learning is outdoor learning. It affects the interest in learning and student learning outcomes (Ali, 2008; Syawiji, 2009, Amini, 2015). However outdoor learning activities are rarely carried out in learning as it relates to the difficulty of class management, making it difficult for teachers and in its implementation and requires a tight of time management (Santiningtyas et al., 2012).

Though many advantages gained by utilizing the environment as a learning resource. Through the utilization of field around the school would allow students to learn directly about the natural phenomenon based on observations of its own so that the learning process more meaningful (Zwick & Miller, 1996). Outdoor learning needs to be repeated to create learning fun and

humanist. Learning is considered able to stimulate the students to improve the quality of learning in all aspects (affective, cognitive and psychomotor) to involve more senses of sight, auditory senses, sense of touch, sense of smell to the students and provide a more memorable experience about the subject.

Based on the results of previous research, Santiningtyas et al., (2012) show that implementation of outdoor learning inquiry-based significantly influence student learning outcomes, as well as research from Solichah et al., (2013) with the development of experimental pieces in the inquiry-based integrated IPA outdoor learning as feasible and more effective in learning. Based on the background and identify the problem, this research aims to develop science process skills and problem-solving abilities based on outdoor learning in junior high school.

## METHODS

This study uses a Mixed Methods design embedded experimental Model (Creswell, 2013). This method comprised of two basic processes, that is quantitative process accompanied by a qualitative process which embedded inside and the process based on a qualitative interpretation of the results.

The quantitative research design using Pre-Experimental design using a design The One Group Pretest-Posttest Design. Early research before is treated by administered problem-solving tests as preliminary data of students pretest. After being given the treatment, problem-solving tests given to get the data again from students posttest. While the design of qualitative research was conducted during the intervention using outdoor learning when intervention gave the observations to determine the science process skills of students during learning.

The instrument used in this study comprised of science process skills observation sheets and pretest and posttest questions used to measure students' problem-solving abilities. Data analysis techniques to determine the qualitative data of science process skills used by reducing the data, encoding and interpretation of the results process skills are applied every meeting on the outdoor learning. While the data of problem-solving abilities performed by using an N gain score or the normalized gain.

$$g = \frac{X_m - X_n}{100 - X_n} \quad (1)$$

With:

$g$  = gain score

$X_m$  = posttest score

$X_n$  = pretest score

After calculation, the results are confirmed by gains normalized criteria; a)  $g < 0.3$ ; low, b)  $0.3 \leq g < 0.7$ ; medium, c)  $g \geq 0.7$ ; high (Hake, 1998).

## RESULTS AND DISCUSSION

Learning activity in this study is in principle by the lesson plan that had been developed, which applying outdoor learning adapted from Eggen & Kauchak (2012) which is applied to a VII class at one of junior high school in Jember. The outdoor application learning was done in six main stages i.e. the identification of the problem, examine the question (to formulate the problem), create a hypothesis, collect data, analyze the data and make conclusions, as well as build and communicate the report. These six stages are adjusted to the character of IPA lessons that require a variety of methods to practice and improve the science process skills and problem-solving ability of students.

Aspects of science process skills contained in the outdoor learning include observation, formulating questions, formulate hypotheses, make observations outside the class, create data, classifying and analyzing data, drawing conclusions, communicate, and apply concepts and make predictions. Aspects of science process skills results are shown in Table 1.

Based on Table 1, in general, the average value of science process skills in good categories, that is equal to 75.33. These results are due to in learning; students are invited to make direct observations of the neighborhood where they live, which is one of the most effective ways to portray the concepts studied by aligning themselves as much as possible to reality (Liu et al., 2009).

Application of outdoor learning makes the students active and no longer memorize the concepts, but students can construct their knowledge. So that these lessons can also develop science process skills directly in the field, making the lesson more clear and concrete, easy for students to understand the lessons, stimulate students to more actively observe and try themselves so that students are more motivated and enthusiastic in observation (Wahyuni, 2016). According to Arend (2008) expressed curiosity something that can motivate students to construct knowledge

students actively, so that the student-centered learning process (student centered).

**Table 1.** Average Value of Students Science Process Skills (KPS)

KPS aspect	KPS	
	Average Value	Category
Observation	80.60	Very good
Formulating Questions	78.90	Good
Formulating Problems	54.00	Less
Observation Outside the Class	90.25	Very good
Creating Data	74.80	Very good
Classifying and Analyzing Data	72.30	Good
Formulating Conclusions	75.25	Good
Communicate	80.30	Very good
Apply the Concepts and Making Predictions	71.60	Good
Average	75.33	Good

The problem-solving ability of students is measured by using a posttest comprised of five questions in the form the description consisting of four (4) stages, problem analysis, planning, problem-solving, problem-solving alternative, and reflection. The results of data analysis the average score of pretest and posttest of each stage is presented in Table 2.

**Table 2.** The results of the comparison of Problem Solving Ability pretest and posttest score

Stage	Pre-test	Post-test	N gain	Category
Problem analysis	60.24	88.56	0.71	High
Problem Solving Planning	36.75	76.65	0.63	Medium
Problem Solving Alternative	56.30	75.45	0.43	Medium
Reflection	40.56	73.45	0.55	Medium
N-gain Average Score			0.58	Medium

Based on Table 2, in general, the problem-



solving ability of students has increased to the score of N gain average of 0.58 in the medium category. It is because of students already familiar and well-practiced in outdoor learning. So that students become familiar to analyze and solve real problems that are going on around him, collecting data based on observations, make hypotheses, discussion, and students can make their conclusions related to the observation and study have been received.

The presence of triggers to be a problem in outdoor learning made students more interested in and challenged to learn. Where in the steps of outdoor learning, students are encouraged observation outside the class makes the students acquire direct experience of what students learn and interact directly with the object being observed so that students have a strong interest in learning from within himself. It is according with the opinion of Tolga (2008) which states that a child will be interested in learning when he learned it was a little known or enjoyed its benefits so that it can grow the curiosity.

Improved problem-solving ability is possible due to the application of outdoor learning, students familiar to solve problems that led to the learning becomes more meaningful. It is due to students are invited to learn outdoors to take advantage of the environment as a learning resource, thus making the concepts/facts related to the subject can be easily mastered students through observations on a concrete situation. It is according to Yuniastuti (2016) states that the use of learning strategies to use in real world problems as a context for students to learn, making the students can improve their critical thinking skills and solve problems, and get the concept of knowledge.

Outdoor learning is the positive impact on problem-solving skills and science process skills of students. Students become used in preparing the material to be learned by studying seriously, if there were not understood or encounter difficult problems related to everyday life, they carry out identification of problems and find solutions to solve these problems, ask the teacher or a person who could provide an explanation regarding the problems encountered, reading, or looking out from a variety of sources/media.

Positive impact on outdoor learning is also a permanent impact on the students. Students maintain their learning style and attitude of environmental care. This finding is evidenced by completion of a problem using problem-solving stages, as well as the attitudes of the students when there is trash scattered, they immediately

took to be thrown in the trash and reminding each other for not littering. With the existence of the positive attitude, it will improve the ability to solve problems and practice students' science process skills which will further improve learning outcomes. It is according to Liu et al., (2009) research which states that students show a good positive attitude towards learning strategy and outdoor learning accompanied by group work.

## CONCLUSION

Based on the results of research and discussion, we can conclude that (1) science process skills that exist for the application of outdoor learning scored the highest with very good criteria found in four aspects that observation, observation outside the class, create data, and communicate. Good criteria found in four aspects, formulating questions, organizing data, formulating its conclusions, and applying the concept/prediction. While the average score was lowest for the aspects of formulating hypotheses. (2) Problem-solving abilities. During the learning process of outdoor learning has increased by an average of 0.58 N-gain in the medium category.

Based on the discussion and findings. The application of outdoor learning can be teachers use as an alternative to learning because it proved able to teach you how to learn efficiently and can optimize the science process skills and problem-solving abilities. Sometimes learning conducted in the classroom and sometimes students are encouraged to learn in a different atmosphere outside the class so that the enthusiasm for learning can increase student learning and evolve.

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## THE DEVELOPMENT OF SCIENCE DOMAIN BASED LEARNING TOOL WHICH IS INTEGRATED WITH LOCAL WISDOM TO IMPROVE SCIENCE PROCESS SKILL AND SCIENTIFIC ATTITUDE

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### ABSTRACT

This research was conducted to: (1) improve the science domain based learning tool which is integrated with appropriate local wisdom for Science learning material “Object Change Around Us” for students grade VII of Junior High School, (2) know the effectiveness of science based learning tool which is integrated with developed local wisdom to improve science process skill and scientific attitude of students grade VII of Junior High School. This research was a research and development which adapt 4D Thiagarajan model which include four steps, they were: (1) define, (2) design, (3) develop, and (4) disseminate and Borg & Gall development model which was done into 7 steps, they were: (1) research and information collecting, (2) planning, (3) developing preliminary form of product, (4) preliminary field testing, (5) main product revision, (6) main field testing, and (7) operational product revision. The research result showed that the science domain based learning tool which was integrated with developed local wisdom were: (1) appropriate to be used for science learning material “Object Change around us” for students grade VII of JHS, (2) effective to improve science process skill and scientific attitude of students grade VII of JHS.

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**Keywords:** learning tool; science domain; local wisdom; science process skill; scientific attitude

### INTRODUCTION

Science accomplishment of students in Indonesia is nowadays left behind from other countries. Based on the result study by Trends in International Mathematics and Science Study (TIMSS) year 2011, it was known that science achievement of Indonesian students took number 40 with the score 405 among 42 countries (Martin, Mulis, Foy, Stanco, 2012). The same result was also showed by Programme for International Student Assessment (PISA) study year 2012, in which the level of literal science by Indonesian students placed 64 among 65 countries with the average score of 382, very far from the average

of all participants who reached 501 (Kelly *et al.*, 2013).

The process of science learning in Indonesia is having some weaknesses. Suastra (2005) stated that almost (90%) the purposes of science learning at school were directed to science achievement (science product) and the rests were directed to the skill process and attitude with scores. This condition showed that science learning seemed unworthy for students. Science learning still underlined on only cognitive aspects. Those were only memorizing some formula and concepts. Students less knew facts, principals, law and theories about science. Besides, the purpose of learning on process skill aspects was not optimal in science learning. It was also reaffirmed by Collette & Chiapetta (1994) who stated

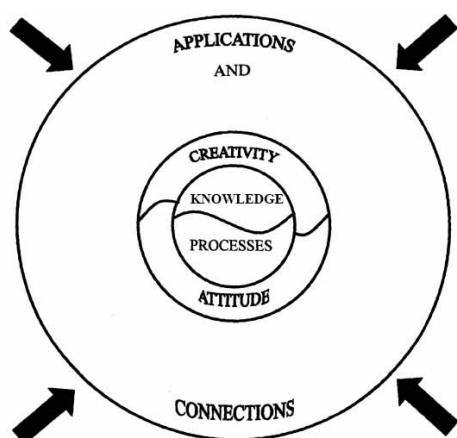
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most science learning at school only pointed on cognitive purposes and ignored affective ones including attitude, motives, and value. Science learning should be covered in a funny and interesting situation because students learnt contextual things (Bimo, 2013). Science concepts learnt were related to the phenomena experienced and faced by students in daily life. Science learning had to be oriented on science natures.

Science natures consists of 4 elements, science as a process, science as a product, science as a skill development, and science as an application. These four science natures should be reached together during learning process (Erina & Kuswanto, 2015). Science firstly was seen as a knowledge about universe accumulated through history records. Then the attention to its process appeared, it was skill needed to find new knowledge. From here then science natures were known as content and process. McCormack & Yager developed taxonomy education of science into five domains which were considered they could answer all science aspects in learning, they were knowledge, process of science, creativity, attitudinal, and application and connections domain (McCormack, 1995). These five domains were the development of bloom taxonomy which had 3 domains in learning. With these five developed domains, students would get more meaningful learning and they were expected to help students improve their result study.

Five science taxonomy domains were presented in Figure 1 (Akçay & Yager, 2010). The focus of science learning was generally on knowledge and process domain. This focus by some teachers was then developed into attitude and creativity domain. Science learning should stimulate students to apply and combine concept and process skill with reality.



**Figure 1.** Five domains in science education taxonomy

Based on the first study using questionnaire and observation done in SMP N 1 Paranggupito, SMP N 2 Paranggupito, and SMP Pancasila 13 Paranggupito Wonogiri Regency, it was taken the information that learning models belonging to teachers were not developed individually and they only adopted from materials arranged by MGMP. Science learning done till now has not developed science domains, especially science process domain and attitude domain. Science teachers in Paranggupito subdistrict also stated the absence of science domains based learning material which was appropriate and effective to improve process skill and scientific attitude of students so that it needs some improvement. Based on this first data study, some materials based on science domain were needed to improve science process skill and scientific attitude among students.

Science process domain emphasized the use of some process skills to learn how scientists thought and worked. Yager (1992) stated that many scientists worked by using some specific process skills. How they thought and worked were important parts needed to be applied on students during learning process. Science process domains were: observing and imaging, clarifying and organizing, measuring and drawing chart, communicating, predicting and concluding, proposing hypothesis, studying hypothesis, testing hypothesis, identifying and controlling variables, interpreting data, making instruments, or using simple tools and models. McCormack (1995) stated some science process skills were: (1) observing and imaging, (2) classifying and organizing, (3) measuring and drawing chart, (4) communicating, (5) predicting and inferring, (6) making hypothesis, (7) testing hypothesis, (8) identifying and controlling variables, (9) interpreting data, and (10) constructing and using instruments, simple equipments and models.

Policy system in Indonesia had given a big opportunity for teachers to integrate local wisdom with learning process. The fact on the field, integrating local wisdom with learning process has still faced some problems. The main problem was that teacher does not know how to integrate environment potential with learning process exactly (Alexon, 2010). Besides, Widowati (2010) revealed some factors why teacher did not use local wisdom in learning process were their outnumbering onus in teaching, the absence of adapted models, facilities, fund, and time.

Local wisdom is the original society knowledge. Local wisdom for some people was ignored because the main view of knowledge from western was seen to be the strongest and the most



useful. Science learning in Indonesia could not ignore culture contribution nor local wisdom. Students could not separate from value developing in the society, with many ethnic background and culture (Sajidan *et al.*, 2015).

Many valuable local wisdom have not been integrated with learning process. Integrating local wisdom indeed has been done by some teachers in Indonesia. It was still limited. Atmojo (2015) stated although local wisdom has been implemented in curriculum, not all students get the knowledge and they felt this implementation was only an extracurricular that were to follow. Students have not understood the value of technology, science and local culture value, so they have no knowledge and appreciation towards local wisdom around them.

Science process skill is skill that could be trained and it represented scientist behavior. Science process skill facilitates science learning, makes sure students' active participation, and trains them in learning, and also trains them how to think and work like scientists. Science process skill was divided into two, they were basic process skill and integrated process skill. Basic process skill included observing, taking conclusion, predicting, using time and space relation, and using number. Integrated process skill included controlling variables, defining operational, formulating hypothesis, formulating models, interpreting data and experimenting (Raj & Devi, 2014).

Yager (2012) explained that attitude domain emphasized on humanity, value, and skill to make decision that was needed to develop. This domain included: (1) developing positive attitude of students towards science in general, science in school, and science teachers, (2) developing positive attitude of students towards themselves, for example through confidence *I can do it*, (3) digging human emotion, (4) developing care and respect towards others feeling, (5) expressing private feeling through constructive ways, (6) making decision on private problems, and (7) taking decision related to environment and social (McCormack, 1995).

Scientific attitude is different from attitude towards science. Although both concepts have relation but there is significant difference. Attitude towards science is a tendency on feeling happy or unhappy towards science, for example thinking science is difficult to learn, less interesting, boring, or the opposites of them. whereas scientific attitude is an attitude belonging to scientists in searching and developing new knowledge, for example objective towards facts, careful, responsible, open minded, always want to observe, etc

(Bundu, 2006). Scientific attitude according to Harlen (Bundu, 2006) includes: curiosity, respect to data/fact, think critically, discovery and creativity, open minded and cooperative, perseverance, care towards environment.

Based on those backgrounds, this research is conducted to: (1) develop based science learning materials which is integrated with appropriate local wisdom for science learning with material Object Change around us for students grade VII JHS, (2) know the effectiveness of science domain based learning material which is integrated with developed local wisdom to improve science process skill and scientific attitude of students grade VII JHS.

## METHOD

This research was research and development. This research developed a product as science domain based learning material which was integrated with local wisdom to improve science process skill and scientific attitude of students. Developed learning materials consisted of syllabus, study plan, worksheet and assessment for JHS material grade VII with theme Object Change around us.

Development procedure was adopted from 4D Thiagarajan model which included 4 steps, they were: (1)define, (2)design, (3) develop, and (4)disseminate (Thiagarajan & Sammel, 1974), and development model of Borg & Gall which included 10 steps, they were: (1) research and information collecting, (2) planning, (3) developing preliminary form of product, (4) preliminary field testing, (5) main product revision, (6) main field testing, (7) operational product revision, (8) operational field testing, (9) final product revision, (10) dissemination and implementation (Borg & Gall, 1983). Development model of Borg & Gall in this research was done till step 7.

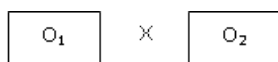
Define step (research and information collection) was the first step research and first data collecting. Activities done were literature study, introduction study, and need analysis. Literature study was done by studying theory about learning material, science domain, local wisdom, science process skill, scientific attitude, and other supportive theories. Introduction study was done to know the problems and the product needed on the field. Result of this introduction study was then studied to determine the needed product. Curriculum analysis and material analysis were also done in this step. Curriculum analysis was done by identifying standard competence that students must poses and determine the indicators

of achieving this standard competence. Material analysis was done by determining concept that will be taught and making map concept to ease developing learning material.

Design/planning step was step of designing product that will be developed. The activity done was determining product component, purpose of developing product and target of product user. Determining product component was accompanied with determining forms for each component, they were syllabus, study plan, assessment, and LKPD.

Develop step was step of developing product. The activities done in this step were: (a) develop preliminary form of product, it was step of developing first product, arranging instruments, validating product, and first revision; (b) preliminary field testing, it was testing test on the field (limited). Test was done to know the product effectiveness of science domain based learning material which was integrated with local wisdom to improve science process skill and students' scientific attitude. The result of this limited test was used to repair the product; (c) main product revision, it was step of revising first result test field (limited). The revision was done by repairing product based on the result of limited test.

First test was done by using experiment design One-Group Pretest-Posttest Design. This experiment design was seen like Figure 2 below (Sugiyono, 2014).



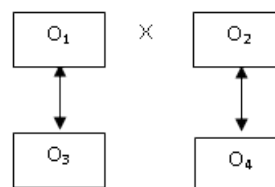
**Figure 2.** One-Group Pretest-Posttest Design

This experiment design was done by measuring first subject skill before and after treatment. The result of the measurement was then compared to know the effectiveness of science domain based learning material which was integrated with local wisdom in improving science process skill and students' scientific attitude.

The activities done in disseminate step were main field testing and operational product revision. Main field testing was done by using experiment design of Pretest-Posttest Control Group Design. In this design there were two groups taken randomly, then both groups were measured before and after treatment. Experiment design of Pretest-Posttest Control Group Design was shown in the Figure 3 (Sugiyono, 2014).

Test was done to know the effectiveness of learning material product based science domain which was integrated with local wisdom in improving science process skill and students'

scientific attitude. After doing main field testing, the analysis of research purpose was done. The purpose that was not achieved became a note, so the same mistake did not occur when the product was published. The result of main testing was done to revise the product.



**Figure 3.** Pretest-Posttest Control Group Design

The research was done on December 2015 – February 2016. It was in SMPN 2 Paranggupito, Wonogiri Regency. The subjects tested were students grade VII of SMPN 2 Paranggupito in the academic year 2015/2016. There were 65 students with details: (1) first test used 22 students from VII A; (2) main test used 22 students of VII C as experimental class and 21 students of VII B as control class.

The technique of collecting data in this research were test, questionnaire observation, and Focus Group Discussion (FGD). Test was done by using instruments of collecting data in the forms of science process skill questions. This technique was used to measure students' science process skill. Questionnaire was done by using worksheet for teachers in the first introduction study, validation sheet of learning material, validation sheet of science process skill questions, students' scientific attitude questionnaire, and questionnaire response of students towards LKPD. Observation was done by using sheet observation in introduction study. Focus Group Discussion (FGD) technique was used to validate instruments that would be used by validators. FGD was done to get suggestions from experts and friends about the instruments that would be used.

Data analysis in this research used three techniques, they were: (1) analysis of product appropriateness, (2) analysis of validity and instrument reliability, and (3) analysis of developed product effectiveness. Analysis of appropriateness was done qualitatively and quantitatively. Qualitative data were criticism, suggestion and opinion from validators and students towards LKPD. Quantitative data were scores from validators in validation sheet of learning materials and scores of questionnaire responses from students towards LKPD.

Scores from validators were then tabulated and counted its average. The total of average scores

re from 58 questions in validation sheet of learning material was then changed into interval data with 4 criteria scales by category (Depdiknas, 2010) as it was presented in Table 1.

Scores of students questionnaire response towards LKPD were tabulated and counted their total average score. Total average score of 17 questions in students questionnaire responses towards LKPD was then changed into interval data with 4 kategori scales (Depdiknas, 2010) as it was seen in table 2.

The validity of process skill questions and students scientific attitude questionnare in this instrument research was counted based on Aiken's V formula, it was by determining content validity coefficient. Content validity coefficient (V) was counted based on the validators scores towards item from how far this item represented measured construct. An item could represent measured construct if it was relevant with determined indicators.

Aiken's V statistic was formulated as below:

$$V = \frac{\sum s}{[n(c - 1)]}$$

Notes:

V= content validity coefficient

s= r - lo

lo= low validity score

c= high validity score

r= score given by validators

n = total validators

the range of V score was among 0 to 1.00. an item could be valid if it had value  $V \geq 0,50$  (Azwar, 2014).

Skill questions of instrument reliability and students scientific attitude questionnaire theoretically were determined by using Borich (1994) equation:

$$R = 100\% \left[ 1 - \frac{A - B}{A + B} \right]$$

Notes:

R= instrument reliability

A= high frequency score by validators

B= low frequency score by validators

Instrument reliability could be called good if value R was bigger or as same as 75% (Borich, 1994).

Science process skil data in this research were taken through test, whereas scientific attitude data were taken through questionnaire. Scientific attitude data were ordinal which were transformed into interval data. Transformation method used was Method of Successive Interval (MSI) which was explained by Hays (Waryanto & Millafati, 2006), with the help of add program in Successive Interval Microsoft Excel.

The analysis of learning material effectiveness based science domain which was integrated with developed local wisdom to improve science process skill and students scientific attitude in the first test was done by comparing pretest and posttest score of science process skill and students scientific attitude. Statistic test that was done was paired t 2 test. Ho of paired t 2 test for science process skill was that science domain based learning material which was integrated with local wisdom was not effective to improve students skill of science process grade VII JHS. Ho of paired t 2 test for scientific attitude data was that science domain based learning material which was integrated with local wisdom was not effective to improve students scientific attitude in grade VII JHS.

Analysis of the effectiveness of science domain based learning material which was integrated with developed local wisdom to improve science process skill and scientific attitude in the main test was known by comparing gain sco-

**Table 1.** Criteria of product appropriateness

Value	Interval score	Criteria
A	$Mi + 1,5 SDi \leq Mi + 3,0 SDi$	189 $\leq$ 232 Very Good
B	$Mi + 0 SDi \leq Mi + 1,5 SDi$	145 $\leq$ 189 Good
C	$Mi - 1,5 SDi \leq Mi + 0 SDi$	102 $\leq$ 145 Enough
D	$Mi - 3 SDi \leq Mi - 1,5 SDi$	58 $\leq$ 102 Bad

**Table 2.** Response criteria of students towards LKPD

Value	Interval Score	Criteria
A	$Mi + 1,5 SDi \leq Mi + 3,0 SDi$	55,3 $\leq$ 68 Very Good
B	$Mi + 0 SDi \leq Mi + 1,5 SDi$	42,5 $\leq$ 55,3 Good
C	$Mi - 1,5 SDi \leq Mi + 0 SDi$	29,8 $\leq$ 42,5 Enough
D	$Mi - 3 SDi \leq Mi - 1,5 SDi$	17 $\leq$ 29,8 Bad

re of science process skill and scientific attitude between experimental and control class. Gain data was taken by using standard gain technique (Meltzer, 2002).

$$\text{Standard Gain} = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

Gain data was analyzed by using independent t test. Ho for independent t test of science process skill was that science domain based learning material which was integrated with local wisdom was not more effective than learning material that was usually used by science teachers to improve students science process skill in grade VII JHS. Ho for independent t test of scientific attitude data was that science domain based learning material which was integrated with local wisdom was not more effective than usual learning material used by science teachers to improve students scientific attitude in grade VII JHS. Independent t test was done towards science process skill gain and students scientific attitude in both experimental and control class. The measurement of each static test was done by programme SPSS 22 in the level of significance 0,05. The criteria taken was that ho was rejected if its significance score < 0,05.

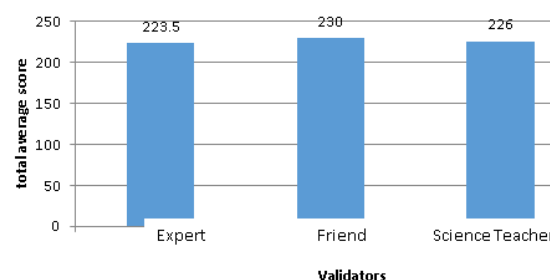
## RESULTS AND DISCUSSION

### Result Analysis of Product Appropriateness

Validation data of learning material from each validators were tabulated for each components and subcomponents from the assessment available in research instrument. The total average score from each validators was counted then changed into qualitative data (interval data) with Likert scale of 4 criteria to know the appropriateness of developed learning material. The result of the appropriateness of science domain based learning material which was integrated with local wisdom was showed on Table 3, whereas the chart score of total average of learning material validation sheet was presented in Figure 4.

Data on Table 3 showed the total score of average given by expert lecturers, friend, and science teachers in order 223,5; 230; 226. The total average score from each validators was chan-

ged into qualitative data (interval data) with Likert scale of 4 criteria and the result were: (1) the appropriateness of science domain based learning material which was integrated with developed local wisdom according to expert lecturers was very good with value A, (2) the appropriateness of science domain based learning material which was integrated with developed local wisdom according to friends was very good with value A, (3) the appropriateness of science domain based learning material which was integrated with developed local wisdom according to science teachers was very good with value A.



**Figure 4.** Chart of total average score of learning material validation sheet

With those, science domain based learning material which was integrated with developed local wisdom was appropriate to use in learning process with material Object Change around us for students grade VII of JHS.

Questionnaire response data of students towards LKPD were got from questionnaire. Questionnaire response data of students towards LKPD were tabulated then counted their total average. Then the total average score was changed into Likert scale of 4 criteria. The recapitulation of students data analysis response towards LKPD was presented in Table 4. The data in table 4 showed that developed LKPD had very good criteria with value A. So, the developed LKPD was appropriate to use in main test.

The recapitulation of students data analysis response towards LKPD was presented in table 5. The data in table5 showed that developed LKPD had very good criteria with value A. So, the developed LKPD was appropriate to use in learning process.

**Table 3.** The result analysis of learning material appropriateness

Validator	Total average score()	Interval score	Value	Criteria
Dosen Ahli	223,5	A = 189 <<=232	A	Very Good
Teman Sejawat	230	B = 145 <<=189 C = 102 <<=145	A	Very Good
Guru IPA	226	D = 58 <<=102	A	Very Good



**Table 4.** Recapitulation of students response data towards LKPD in first test

Total average score (X)	Interval Score	Value	Criteria
59,7	A = 55,3 <=68 B = 42,5 <=55,3 C = 29,8 <=42,5 D = 17 <=29,8	A	Very Good

**Table 5.** Recapitulation of students response data towards LKPD in main test

Total average score (X)	Interval score	Value	Criteria
58,5	A = 55,3 <=68 B = 42,5 <=55,3 C = 29,8 <=42,5 D = 17 <=29,8	A	Very Good

**Analysis of instrument validity and reliability**

Analysis of instrument validity and reliability was done to know the appropriateness of instrument of science process skill question and scientific attitude questionnaire which were parts of this developed research instrument. The validity of science process skill question was done on each number of questions based on its relevance to the measurement purpose with criteria: relevant, useful but irrelevant, and irrelevant. The validity of scientific attitude questionnaire was done on each number of students scientific attitude questionnaire based on its relevance to the measurement purpose with criteria: relevant, useful but irrelevant, and irrelevant.

The validity of science process skill questions was presented on table 6. The questions consisted of 20 multiple choices (no 1-20). Based on the analysis result in table 6, it was known that question number 3 and 7 had content validity coefficient 0,92, whereas others numbers had 1.00. the reability of instrument theoretically was 80,0 % so it could be said as good reliability. It showed that al numbers of science process skill questions were valid and appropriate to use in this research.

The recapitulation of validity scientific attitude questionnaire was presented on table 7. The questionnaire consisted of 13 questions (no 1-13). Based on the analysis result in table 7, it was known that all numbers of questionnaire

had content validity coefficient 1.00. instrument reliability theoretically was 100% so it could be said to have a good reliability. It showed that all numbers of questionnaire of students scientific attitude were valid and appropriate to use in this research.

**Table 6.** Recapitulation result of science process skill validity.

Number of Questionnaire	V	Note
1	1,00	Valid
2	1,00	Valid
3	0,92	Valid
4	1,00	Valid
5	1,00	Valid
6	1,00	Valid
7	0,92	Valid
8	1,00	Valid
9	1,00	Valid
10	1,00	Valid
11	1,00	Valid
12	1,00	Valid
13	1,00	Valid
14	100	Good
15	1,00	Valid
16	1,00	Valid
17	1,00	Valid
18	1,00	Valid
19	1,00	Valid
20	1,00	Valid
R	100	Good

V= content validity coefficient

R= instrument reliability

**Analysis Result of Product Effectiveness**

The product effectiveness in improving science process skill in the first test was known by comparing pretest and posttest value. Statistic test used was paired t test by using  $\alpha = 0,05$ , the value of significance 0,000. Since the significance value was 0,000 or it was  $< 0,05$  so  $H_0$  was rejected. So, by using  $\alpha = 0,05$  it could be concluded that science domain based learning tool which was integrated with local wisdom was effective in improving science process skill of students grade VII of JHS.

**Table 7.** recapitulation result of scientific attitude

questionnaire validity.

Number of Questionnaire	V	Note
1	1,00	Valid
2	1,00	Valid
3	1,00	Valid
4	1,00	Valid
5	1,00	Valid
6	1,00	Valid
7	1,00	Valid
8	1,00	Valid
9	1,00	Valid
10	1,00	Valid
11	1,00	Valid
12	1,00	Valid
13	1,00	Valid
R	100	Good

V= content validity coefficient

R= instrument reliability

The product effectiveness in improving scientific attitude in the first test was known by comparing pretest and posttest value of students scientific attitude. Statistic test used was paired t test by using  $\alpha = 0,05$ , the value of significance 0,000. Since the significance value was 0,000 or it was  $< 0,05$  so  $H_0$  was rejected. So, by using  $\alpha = 0,05$  it could be concluded that science domain based learning tool which was integrated with local wisdom was effective in improving scientific attitude of students grade VII of JHS.

The effectiveness of science domain based learning tool which was integrated with developed local wisdom in improving science process skill in the main test was known from statistic test by using independent t test on the data of science process skill. Statistic test by using independent t test on the data of science process skill resulted significance value 0,009. Since the value was 0,009 or it was  $< 0,05$ ,  $H_0$  was rejected. So, by using  $\alpha = 0,05$  it could be concluded that science domain based learning tool which was integrated with local wisdom was more effective than usual learning tool used by teachers in improving science process skill of students grade VII.

The effectiveness of science domain based learning tool which was integrated with developed local wisdom in improving science process skill in the main test was known from statistic test by using independent t test on the data of scientific attitude. Statistic test by using independent t test on the data of scientific attitude resulted significance value 0,008. Since the value was 0,008

or it was  $< 0,05$ ,  $H_0$  was rejected. So, by using  $\alpha = 0,05$  it could be concluded that science domain based learning tool which was integrated with local wisdom was more effective than usual learning tool used by teachers in improving scientific attitude of students grade VII.

## CONCLUSION

Based on the data and result analysis, it could be concluded that science domain based learning tool which was integrated with developed local wisdom were : (1) appropriate to use for learning tool with theme Object Change around us for students grade VII of JHS, (2) effective in improving science process skill and scientific attitude of students grade VII of JHS. Science teachers are expected to use this science domain based learning tool which is integrated with developed local wisdom during learning process at school. This integrated media is effective in improving science process skill and scientific attitude of students. Students will also understand more the nature of science with this science domain learning tool.

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## STUDENT'S SCIENCE LITERACY IN THE ASPECT OF CONTENT SCIENCE?

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### ABSTRACT

The fundamental issue is the growing use of scientific information possessed by students to solve problems in daily life and produce useful scientific source from scientific literacy. The purpose of the research was to analyze and describe the ability of a student science concepts from the aspect of scientific literacy that includes aspects of scientific knowledge, scientific competence, scientific context as well as the factors that influence the students' science literacy skills. This research was quantitative descriptive analysis. The instrument used was a matter of objective 40 along with the reasons of the physics concept and biology concepts that are used to measure aspects of scientific knowledge, scientific competence, and scientific context, while the students' attitudes towards science and science teaching and learning strategies measured by questionnaire instrument. Instruments used included multiple-choice test questions reasoned and questionnaires (the attitude of science and science teaching and learning strategies). Based on data analysis it was known that the ability of science literacy PGSD UMK students varied, 66.2% of students were at the level of nominal and 33.8% of the students were at the functional level. It showed that 66.2% of students already had a concept for connecting science with other disciplines, could write a scientific term, but students still had misconceptions, while 33.8% of students considered the theory and explained concepts correctly, but they had a limited understanding and were difficult to connect to the concept of his own opinion.

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**Keywords:** science literacy; skill; content aspect

### INTRODUCTION

Every individual needs to determine option or decision based on his scientific information to solve daily life problems and produce a beneficial scientific product which has a source from science literacy. Science literacy is one of science education's target (Hoolbrook & Rannikmaa, 2009).

Norris & Philips (2003) found that one of the main purposes is to establish society scientific literacy. Scientific literacy consists of knowledge and understanding of scientific concepts and

scientific process that is needed by someone in making decision, cultural and economic productivity (Dani, 2009).

Furthermore, scientific literacy can be promoted by problem solving skill in personal and social (Lederman et al., 2013). Therefore, its development on every individual is extremely important.

Every individual is demanded to have scientific literacy covering its scientific knowledge, scientific process skill, and scientific attitude. With this, scientific literacy development is important. Every individual is obligated to have scientific literacy including scientific knowledge, scientific process skill, and scientific attitude.

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Scientific literate society is able to use scientific knowledge, identify questions, and draw a conclusion based on the evidence, in accordance to understand as well as to generate decision related to nature and its changes done to nature through human activities.

Laugsch (2000) suggested that the development of scientific literacy was very important because it could contribute to the social and economic life, as well as to improve making decision skill at the community level and personal. It was strengthened by Poedjiadi's statement (2005) that an individual has scientific literacy skill and technology. It is a person eligible to solve problems by using scientific concepts gained in education based on his level, recognizing product of technology around him, and its positive impact, or the use of the product and its maintenance, creative in creating simplified product technology so his learners are able to decide based on local values and custom.

PISA-OECD (Program for International Student Assessment-Organization for Economic Cooperation and Development) in 2006 had measured scientific literacy that showed the low level in Indonesia, 29% of the content, 34% for the process, 32% for context (Balitbang Kemdikbud, 2011). Its low level was caused by the understanding about science learning which leads students to incomplete science literacy formation of the students understood by the teachers. In the aspect of content, it was caused by science learning process which still focused on memorizing, so the students did not understand what they learned but only memorized (Jufri, 2013). This low scientific literacy on learning process aspect was a focus for teachers (Ekohariadi, 2009). The student's activity is only listening to teacher's explanation; then students learn science as products instead of process, attitudes, and applications. The next aspect is the contextual aspect; teachers are not fully connecting the material with the student's environment (Tjalla, 2009). Whereas, phases of teaching and learning in scientific literacy according to Holbrook (2011) include contact phase, curiosity, elaboration, decision making and re-contextual. In addition, according to Rubini et al.' (2016), The problem about the low scientific literacy abilities of students can not only be solved by applying the model/method/strategy of science learning based on constructivism. The classroom environment and climate are an important component of the students' literacy skills. Likewise, the school infrastructure, human resources, organization, and management bring a very significant influence to students' achieve-

ment literacy. Another factor affecting the ability of students' scientific literacy is a teacher. Therefore, scientific literacy measurement is needed to figure out its improvement of human source quality especially the students of the primary educational department as the candidates of elementary teachers.

The measurement is important to figure out its improvement on human source quality of the students as a teacher candidate. Students are expected to create an innovative learning and support scientific literacy, so the next generation (primary educational students) will have higher competitive performance. It is based on the field reality and becomes a demand to promote learning process activity. The initial learning which focuses on knowledge needs to move on holistic learning based on skills, attitudes, and literacy to solve various problems. Through this, the students must be capable of dealing with the way of teaching science appropriately. This is in accordance with the opinion of Putra et al.' (2016) which revealed that learning science should equip teachers with professional knowledge.

The focused problem in this research is How the scientific literacy skill distribution of the students is seen from nominal, conceptual, functional and multidimensional levels and what factors affect students' scientific literacy skills? The purpose of the research is to find out the distribution of the students seen from nominal, functional, conceptual and multidimensional levels as well as to investigate and describe factors affecting the primary educational students' scientific literacy skills.

## METHODS

The study was conducted on even semester. The subjects were the 4<sup>th</sup> semester of primary educational students of Universitas Muria Kudus. The samples were taken through Slovin calculation formula and gained 77 students in Applied Science course. Samples were taken to represent all the students who had studied Science Concept course (in the previous semester) with a sampling distribution in Table 1.

In the research, the researcher uses the descriptive quantitative method. It was quantitative since the approach used in the proposal, process, hypothesis, action field, data analysis and data conclusion until its report used measurement, calculation, formula, and numerical data aspects (Ginting, 2008). On this research, the researcher did not do any special treatment toward sample without a control group or experimental

group.

**Table 1.** The distribution and the Number of the Research Sample

Number	Criteria	Number of the students
1.	The A – score gaining students	17 students
2.	The AB – score gaining students	25 students
3.	The B – score gaining students	25 students
4.	The ≤ BC – score gaining students.	10 studnets
Total		77 students

The instruments used to gain the data were; questionnaire and test to measure the student’s attitude toward science and to find out its learning strategy appropriately in a science course. The questionnaire had three options, such as agree (A), doubt (D) and disagree (DA) then were converted into Likert scale. whereas test consisted of 40 multiple choices and attached with reasons relating to scientific content, scientific competency, and scientific context aspects.

After the data had been taken, the test toward the data was conducted. The data were quantitative in the form of a score of scientific literacy mastery, students’ attitudes and the expected teaching and learning in science to support scientific literacy. The quantitative and qualitative data would be analyzed descriptively to find out the data intention, or the result would be used to draw a conclusion. And this test was used to find out the correlation between scientific literacy with response questionnaire answered by the students. To calculate, the writer used correlative product formula from Karl Pearson.

**RESULTS AND DISCUSSION**

**Analysis Capabilities Literacy Science Students**

Students’ scientific literacy skill from Primary Educational Teacher Department was measured by the test and non-test instruments. The test instrument consisted of 40 questions objectively with reasons about science and biology concepts that were used to measure aspects of scientific knowledge, competence, and context. The result scores for students’ scientific literacy skill was shown in Table 2.

**Table 2.** Recapitulation of scientific literacy of the students

High Score	54
Low Score	21
Average score	36
Scientific Literacy Level	66.2% students are in nominal level 33.8% students are in functional level

**Table 3.** Recapitulation the measurement results based on indicators of science competence

Indicators	Number of question	Average
Identifying scientific issues	1.4. 7. 9.13.17.21. 23.24.30. 33.37.38	39.8
Explaining phenomena scientifically	2.5.10.14.16.19.20. 22.25.27. 34.35.39.40	34.4
Utilizing scientific evidence	3.6.8.11.12.15.18. 26.28.29.31. 32. 36	35.5

**Table 4.** Measurement recapitulation based on scientific context indicators

Indicators	Number of question	Average
Health	1. 9. 12. 13.18.22. 30.32.37	38.4
Natural resources	4.7.19. 24. 25. 27. 36	32.3
Environment	2.8.5.11.23.31.33.34	28.2
Disasters	10.14. 16. 20. 28. 35. 38.39	42. 0
Science and technology	3.6.15.17.21.26.29.40	38.3

It resulted that 66.2% students were in nominal level while 33.8% of them were in functional level. Based on this data, the students basically had obtained concept to relate science with another discipline; they could write a scientific term, but they still had misconceptions or mistake on the concept. Meanwhile, 33.8% of the students remembered the theory and explained the concept correctly, but they had limited understanding and difficulties to relate the concept into their personal answers.

This lack of literacy level was caused by various factors, internal and external. One of the most affective factors is students’ educational background before enrolling the university. Not all students of Primary Educational Department were from science course major background.

They were from various majors, such as sociology, science, language, technique, economy, accountant and clothing, so their ability to master the concept of science might vary. It was relevant to the research done by Ekohariadi (2009) who stated that one of the factors affecting scientific literacy was educational background. Educational background, experiences and parents guidance would motivate their children well. In addition, one of the natural factors reflecting opinion, perception, affection and action – was intelligence (Baron & Byrne, 1991). Therefore, the students from science major background clearly had better scientific skills than the non-science majored students. But this could not be ignored in a sustainable manner. According to Jufri et al.' (2016) in his study, if the reason for students' low ability was a teacher, then, of course, it would be closely linked to their patterns of teaching if one day becomes a teacher. Therefore, in order to develop students' ability to become prospective teachers, teaching and learning process in the faculty should be directed to provide students to have scientific skill reasoning to support scientific literacy.

The scientific literacy score results could be analyzed on every aspect to analyze their skills in detail. From the recapitulation of scientific competence aspect (table 3), it was known that the highest average score was on identifying the scientific issue. Meanwhile, its lowest score was in explaining phenomena scientifically. Based on the result, it was known that basically, the students had enough theoretical ability or scientific concept, could identify or determine a problem but still had difficulties to explain the phenomena or problems well. Based on the nominal and functional level, it was said that the students basically knew the theory but still had a misconception and could not explain the concept with their answers (Bybee, 2009). It could be seen during the learning process. When they were given a problem, basically they could mention and identify its root, but they still faced difficulty in analyzing complexly by relating various concepts or seen from other disciplines.

Other affective factors were students' lack access, and literacy, one of them is learning source. The students did not have science concept book. They only had a *handout* from the lecturer although the lecturer had asked them to have books related to the materials for University level. However, some of them admitted having difficulties while learning the books because most science concept literacy provided in the library were translation and some of them were still in English.

The recapitulation of students' scientific literacy skills based on science aspects showed that the indicators of health, natural resources, and technology science had nearly equal average scores, but there was a gap on indicators of environment and disaster. The highest average score in the disaster was 42%, whereas its lowest average score is 28.2%. This low indicator of analyzing of the environment and social issues caused the low level of students' scientific literacy. Marks & Ingo (2009) said that the factor that could improve scientific literacy skills was socio critical-oriented issues to identify, analyze and relate the issue to environment. Moreover, scientific literacy skill could be improved by making a decision of science technology and environment issues (Yuenyong&Pattawan, 2009). Therefore, the students did not have the ability to solve the problems of the environment, so the results of scientific literacy's score were not good.

The indicator of the disaster had the highest score because students could identify the issue and explain various disaster including scientific concept which related to the disaster, its cause, and its impacts. However, the students could analyze and relate the issue of the environment to various concepts and other disciplines. It was because of the issue of environment involved very complex concept and theory. Students could understand environments issues if the students were interested in reading any literature. But, they were not interested in reading many literature except the books from the lecture. Students had homework to summarize and analyze some problem, and their summary had to be related from any literature. 68% students did not understand the content that they wrote. Moreover, the literature was in English. Therefore, Jurecki & Matthew (2012) said that to improve the scientific literacy, students must have the ability to review any literature critically and scientifically.

Basically, the lecturers had applied cross theme learning that related to science, environment, technology and society. But, the students could not have integrated thought, but they were still fragmented in a problem. It was caused by many factors, one of them was intelligence. The students from science background averagely could answer well since they had the concept of science, whereas the students from other educational background found difficulties to explain the concept since they admitted they had difficulties to keep up with the course in detail and the last time they learned was in Senior High School grade X. Based on Treacy & Melissa (2011), the scientific communication improvement gained

from reading, writing, and reviewing journal could improve scientific literacy. In another hand, its initial level of scientific literacy was affected by many factors, such as individual knowledge, speaking askill, social level, educational level and family background (Heath *et al.*, 2014). Scientifically and technically, the factor causing individual literacy was intellectual capacity, including the level of reasoning, attitude, social nature and ability to connect many diciplines (Holbrook & Rannikmae, 2009).

### The Analysis of Students' Attitude Questionnaire

The questionnaire and its learning strategy upon 67 questions represent 4 indicators on attitude aspect and 4 indicators on teaching and learning strategy aspect. The questionnaire consisted of the positive and negative statement. Then the scores taken from the students were correlated into scientific literacy skill to find out its relationship between scientific literacy with the students' attitude toward science and its teaching and learning strategy. Its recapitulation and scientific literacy with the questionnaire score was shown in Table 5.

**Table 5.** The Recapitulation of Scientific Literacy and Scientific Attitude Relationship

Indicator	Total	Large correlation value
Questionnaire attitude	15515	0.37%
Students' attitudes towards science	4348	13.3%
Science learning and teaching strategies	9065	-8.2%
Support scientific investigations	682	-0.52%
Confidence	1136	2.95%
Interest in science	1229	22.44%
Responsibility towards natural resources and the environment	1301	14.3%
Submission of materials	3617	-2.22%
Learning model	2428	8.46%
Participation	1816	-6.15%
Evaluation	1204	-13.92%

Based on Table 5, it was known that the students had an interest in science. It was proven from responsive questionnaire stating that its total achievement average score was 86.68 or in the

category of very good. Then, responsive questionnaire score was correlated with students' scientific literacy skills.

The analysis showed that the students had interest toward science. It was proven from the responsive questionnaire stating that the total average score of the students was 86.68 or was categorized as very good. The questionnaire was correlated with scientific literacy skills and gained score 0.37. The responsive questionnaire attitude consisted of two variables that were student attitude toward science and its learning and teaching strategy. The average scores of the student's attitude variable towards science iwas 85.56. If the result was correlated with scientific literacy skills, the result was 0.1333. It means 13.3% of ability was affected by students' attitudes towards science, whereas 86.7% was affected by other factors and caould be concluded that there was a positive relation between students' attitudes towards science and their skills. The reasonable action theory stated that the attitude affected nature through the process of carefully taking a decision and reasonable (Ajzen & Fishbein, 1980). Attitudes consisted of components such as cognitive, affective and conative (Azwar, 2010). One of the most affective factors of low scientific literacy skills was the students' attitude toward science (Ekohariadi, 2009).

The second variable was teaching and learning strategy. Its average score was 87.23. If the result was correlated with a score of scientific literacy skill achievement, the score was -0.082. The result meant that there was a negative relationship between teaching and learning strategy and their skills. Thus, teaching and learning strategy did not significantly affect students' skill. The learning concept of science was not always done in the class through various learning strategy, but the most important were learning to get skills, both from cognitive, affective or psychomotoric.

The result of science concept score was affected by the learning model used by the lecturers. If the result was correlated with scientific literacy skill score, it was gained 0.0846, so the learning model could affect the skills. Based on the result, 8.46% scientific literacy skills are affected by learning model used. Widiyanti *et al.*' (2015) stated that scientific literacy-based learning set could make students be more active so they could improve their learning outcomes. And Gormally, *et al.* (2009) investigated and gained result that showed students centered learning pattern wiould promote students' scientific literacy skills. Based on the questionnaire, the learning model demanded by students were an ex-



perimental model, outdoor learning, cooperative learning, cross theme learning, and any other innovative learning model. Surpless, et al.' research (2014) show that laboratory based learning could increase students' scientific literacy. Moreover, laboratory and inquiry based learning could promote scientific literacy (Gormally, et al., 2009; Forbes & Zint, 2011).

Moreover, the results of data analysis showed that self confidence had a positive correlation with students' scientific literacy (2.95%) and students' interest in science correlate in scientific literacy (22.44%). It caused students with science course had positive confidence in science and had the self-confidence to answer the questions. Holden (2012) said that self-confidence influence dscientific literacy.

### CONCLUSION

The result showed that science literacy skills 66.2% of the student of Primary Educational Faculty of Universitas Muria Kudus were in the level of nominal and 33.8% of students were the level of functional. It showed that 66.2% of students already had a concept for connecting science with other disciplines, could write a scientific term, but they still had misconceptions, whereas 33.8% of students understood the theory and explained concepts correctly, but hthey had a limited understanding and found difficulty in explaining the concept with their own opinion. Students' attitude toward science had positive correlation towards scientific literacy skills, whereas teaching and learning strategy negatively correlated toward the skills. 13.3% of the skills were affected by students' attitude, while 86.7% were affected by other factors.

Based on the discussions and findings, the lecturer should provide instructional materials science concepts that could develop students' skill and conduct scientific literacy learning skills in cognitive, affective and psychomotor aspects. Students were able to access various literature and information sources, not only from the lecturer and students had to practice to explore higher thinking skills.

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## THE DEVELOPMENT OF ALTERNATIVE ASSESSMENT INSTRUMENT IN WEB - BASED SCIENTIFIC COMMUNICATION SKILL IN SCIENCE EDUCATION SEMINAR COURSE

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### ABSTRACT

Science Education Seminar course aims to develop the communication skill of students. The materials and assignments are given to train how to communicate effectively both written and orally. The tasks consist of the scientific papers analysis, conceptual article draft, and other assignments. It took longer time to assess those assignments with only pencil and paper methods therefore a web-based alternative assessment was designed to assess the assignments. Web-based alternative assessment (e-assessment) can facilitate students and lecturer in the process of collecting and assessing tasks. The validation score by the assessment expert of the four aspects resulted 94,64%, 92,86%, 91,07%, and 92,86% meanwhile the score of expert information systems was 90, 63%. Thus the product can be said as valid in very feasible category with the average score of 81.5%. The percentage of positive responses of students was 84,43% that indicates the product is effective to help students and lecturers in the assessing students' assignment and performance. Therefore, it can be said that the research has met the indicator of feasibility to result a valid and effective product.

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**Keywords:** web-based alternative assessment; e-assessment; scientific communication skill

### INTRODUCTION

Developing skill nowadays has become a course that must exist in the university curriculum. In certain courses, some skills or competencies could be developed like soft skill and hard skill. Soft skill development is highly needed better than a hard skill. Ghautam (2014) explained that hard skill only gives 15% contribution towards someone success. The fact expressed by Ghautam (2014) is one of the considerations for the university to supply their students some competencies so that they could compete in ASEAN Economy Society (AES) or other globalization. So, learning that focuses on solving actual problems need to be designed through a model,

learning media, and right assessment to facilitate the activities connecting the concept and real life (Taufik et al., 2016).

Communication skill is an important skill for teacher candidates. Blandhol (2012) explained that communication is said as effective if it can fulfill someone need. That need could be reached through two ways: with or without paying attention to the needs or other interest. This point is what becomes reference where the appropriate communication is seen from one's need without breaking its relation to another. In integrated science curriculum, one of the competencies that students must have is able to communicate effectively their information, idea, analysis and arguments in many media to the society based on the result study/research in the science field. The course supporting this competence is

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Science Education Seminar. In Science Education Seminar class, students are obligated not only to understand and write analysis paper but also present it as well as seminar demands. Students get a daily score, mid-term test, and final test by searching analysis papers and analyze them, try to write analysis papers, and present it. Thus, students communication skill either oral or written could be developed in Science Education Seminar course. It is in agreement with Brownel et al., (2013) who explained that communication skill needs to be taught if the purpose is to equip future scientists with communication skill either written or oral. Some researches conducted by Klein & Carney (2014), Jones & Seybold (2014), Stewart et al. (2015), dan Chan (2010) also mentioned that written and oral communication skill are a skill that students of the university must have to prepare their career.

The methods used in Science Education Seminar are a discussion, presentation, and portfolio. The assessment done when students are doing presentation or seminar is peer-assessment. Portfolio assessment is taken from structured assignments given by the lecturer in each meeting to develop students' understanding of analysis paper and its kinds. Assessing those assignments is usually done manually by using assessment rubric. Many assignments submitted by students cause lecturer to spend much time to assess. It is obviously less efficient for lecturer work so that some development need to be done to make ease during the assessment of portfolio assignments. Assessment instrument that can ease lecturer in assessing is the web, technology, and information based assessment.

Dahalan & Hussain (2011) defined web-based assessment as the assessment that uses computer application and internet in the learning process. Wusqo et al., (2015), Kay (2014), Muñoz-Cristóbal (2014), Chen (2013), dan Wang et al. (2004), explained that web and technology and information nowadays become tools that are variously used in learning process since they are

cheap and easy to access.

The assessment done through the web (e-assessment) will help lecturer to assess quickly and objectively. From conservation side, web-based assessment in the portfolio will support the less-paper policy because students do not need to print their papers and submit to the lecturer. All assignments will be uploaded, corrected, and assessed by the system so that the result of learning can be seen quickly without leaving many papers.

## METHODS

This research used Research and Development (R & D) approach. R & D research is a basic activity to get needed information, then it is developed to create a product. According to Borg & Gall in Sugiyono (2010), research and development is a method used to develop or validate products that are used in education and learning. The steps of research and development are shown in Figure 1.

The subjects of this research were students of UNNES Science department semester 5 chosen with purposive sampling. The students were limited to those who were taking Science Education Seminar. This research would be conducted in Department of Integrated Science, Faculty of Mathematics and Science, Unnes.

## RESULTS AND DISCUSSION

The methods in this research used nine steps of R and D from Borg and Gall. Those steps were: 1) analyzing potential and problem; 2) collecting information and literature study; 3) designing product; 4) revising design; 5) small scale test; 6) revising product; 7) big scale test; 8) revising product; 9) mass production. The ninth step was not used in this research.

### Analyzing potential and problem

All assignments of Seminar course were still submitted in hard file. Those assignments in-

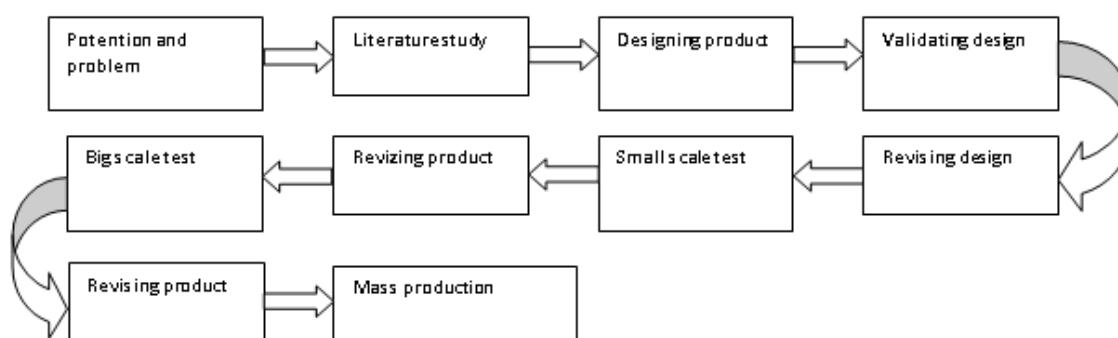


Figure 1. The steps of Research R and D (adapted from Sugiyono, 2011)



cluded analysis papers, making popular articles, and making conceptual articles. Those three tasks were printed and cost many papers. It was against one of Unnes principles, conservation. The Web would become a solution in submitting students tasks. By uploading files to web system, students no longer printed tasks which cost many papers. Every classroom was facilitated with wifi to access the internet so the use of e-assessment could be done during class.

### Collecting information and literature study

In this step, the writer analyzed the curriculum of Science Education Seminar. The tasks that would be given to students were adapted with course goals, expected achievements, and course description. The process of developing the web referred to the relevant researchers. Information sources were taken mostly from research articles in latest seven years, so they were still relevant to be used.

### Designing product

Product design had to fulfill the assessment criteria and presentation criteria. In this step, e-assessment in the form of the web was begun to design either from its layout or content. Researcher team formulated web layout and content. It was done by considering some factors like the curriculum of Science Education Seminar, the ease of using the web by students and lecturer, given tasks, score reference and feedback that would be run on the system. Viberg et al. (2015), Taufiq et al. (2014), Tarhini (2013), Saadé & Galloway (2005) explained that the design of digital application for learning should consider: i) easy use and system usefulness; ii) social norm and work quality; iii) frequency of application use by students when doing individual task; iv) training to use the application for students is necessary to do. During small scale test, students were supposed to train using web e-assessment first with lecturer instruction. those factors according to Motaghian (2013) were not only for students or users but also for web admin/instructor.

Web assessment program could be accessed online on <http://www.e-assessment.web.id>. The lecturer could log in by typing his username and password. The lecturer run as an administrator who could control the whole system. Admin menu available were posting, a final score, students list, add a user, they could be seen in Figure 2.

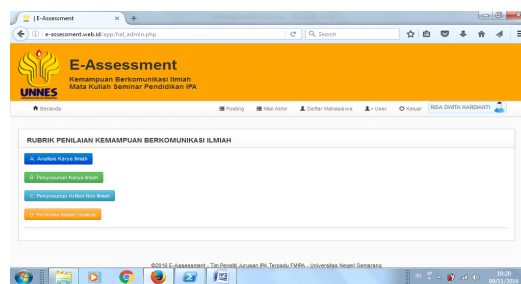


Figure 2. Admin menu in web e-assessment.

### Validating design

All assessments were: An analysis papers assessment (94,64%), B writing analysis papers (92,86%), C writing popular analysis papers (91,07%), and D performance in Seminar (92,86%) were categorized as very appropriate with the percentage of  $\geq 81,25\%$ . So, the assessment has become appropriate to assess the assignments of Science Education Seminar course.

Web e-assessment program was validated by the expert of an information system from web layout, program, and linguistic. The result of expert evaluation towards e-assessment program could be seen in Table 2. E-assessment program was categorized as very appropriate (90, 63%) with percentage  $\geq 81,25\%$ . So, e-assessment has been appropriate to use for assessing the assignments of Science Education Seminar course online.

### Revising design

Design revision was done based on suggestions from assessment expert and information system expert. The weaknesses found was then tested and reduced by repairing the system. The suggestions from assessment expert were: 1) in assessing the abstract of paper analysis the maximum amounts of words should be mentioned; 2) assessment points should be written objectively, not subjectively.

Assessment descriptions given by information system expert were: 1) searching column did not work, if it is not used, it is better to omit; 2) value 0 (zero) could not be input. The range should be from 0 to 100; 3) there is no confirmation in deleting data, it is directly executed. It could make the data suddenly disappear. The existence of confirmation could be used as a warning before deleting data for sure; 4) edit button should not be active when there is no data to input.

**Table 1.** Recapitulation of Assessment Expert Result

Assessment Aspects	Task			
	A	B	C	D
Assessment rubric format				
1.The format is clear to ease the assessment	4	4	4	4
2.The format is appropriate to measure students analysis paper.	4	3	3	4
Content				
1.The measurement is developed based on the purpose of Science Education Seminar Course	3	3	3	3
2.Formulated clearly	4	4	4	3
3.Formulated specificly	3	4	3	3
4.Operational so that it is easy to measure	4	4	4	4
5.Every aspect can be measured objectively	4	3	3	3
6.Can be implemented on web system	4	4	4	4
Language and writing				
1.Use language with correct grammatical and structural Bahasa	4	4	4	4
2.The language is communicative	4	4	4	4
3.The language can be understood easily	3	4	4	4
4.The punctuation is correct	4	3	3	4
Rubric advantages and students' task measurement				
1.Can be used as assessment reference	4	4	4	4
2.Can be used to assess the success of learning process	4	4	4	4
Total	53	52	51	52

**Table 2.** The assessment of e-assessment program by information system expert

Assessment Aspect	Score
The ease of use	
Web e-assessment page could be accessed	4
E-assessment program could be run without any problem	3
The instructions could be understood	3
The program could be easily used	3
Layout	
Design/layout is interesting	3
There are layout consistency, navigation, text, background	4
Font, size, and color of words are appropriate (easy and clear to read)	4
Operating buttons are complete	3
Language and writing	
Use language with correct grammatical structure of Bahasa Indonesia	4
The language is communicative	4
The language can be understood easily	3
The punctuation is correct	4
Total	58

**Small scale test**

After revising the design, next step was small scale test. The product was tested on 5 students. They tried to log into the e-assessment web then upload the file. The lecturer downloaded the file then corrected, gave a score, and gave feed-

back by using menu available on the web. The students then refreshed or re-logged into the program and checked the score and feedback given by the lecturer.

In this small scale test, some weaknesses were still found; 1) there was a student who could

**Table 3.** Recapitulation of students statements (n = 25)

Statements	VA	A	LA	D
I understand all assignments given by the lecturer in Science Education Seminar Course	7	17	1	0
Assignments from the lecturer are very useful in developing written communication skill	19	6	0	0
Assignments from the lecturer are very useful to improve oral communication skill	15	10	0	0
All assignments from lecturer are as I expect in Science Education Seminar course	7	17	1	0
I try to finish all assignments from the lecturer maximally	17	8	0	0
I have followed all rules n doing the assignments of Science Education Seminar course	16	9	0	0
I do not find any difficulty in doing all the assignments of Science Education Seminar	2	21	2	0
I am optimist to get the maximum score because I have done my best in doing the assignments of Science Education Seminar	15	10	0	0
In the future, I will use the knowledge and skill I got from Science Education Seminar in writing or presenting article/analysis paper	17	8	0	0
I recommend uploading all assignments of Science Education Seminar to the web (e-assessment)	13	11	1	0
E-assessment web page is easy to remember	9	13	1	2
E-assessment web program runs well without any problem	1	18	4	2
E-assessment eases me to submit all assignments whenever and wherever without seeing the lecturer	13	10	2	0
I can easily how to use e-assessment	5	19	1	0
I can easily understand the language, instruction, or feedback available on e-assessment web	6	18	1	0
In my opinion, text or writing (font, size, and color) are clear and easy to read	12	12	1	0
In my opinion, e-assessment layout is interesting	11	12	2	0
Feedback in e-assessment motivates me to repair the assignments of Science Education Seminar	14	10	1	0
All feedbacks given by the lecturer really help me repair the assignments of Science Education Seminar	10	15	0	0
Scores given for the assignments of Science Education Seminar are objective	12	12	1	0
I agree if e-assessment is applied in other courses.	8	14	2	1
Total	229	270	21	5

not log in because there was a mistake in inputting students numbers by administrator; 2) the mistake on typing student's name, and 3) students could not upload a file more than 2 MB.

### Revising product

Based on the findings in the small-scale test, the product was revised. The revision included: 1) re-checking data input so that all students numbers were correct and they could log in; 2) correcting students' name; 3) students should compress the file before uploading.

### Big scale test

In this step, there were 25 students using the same e-assessment web like in small scale test. After using the e-assessment web, the students answered the questionnaire was given which consisted of 21 question related to Science Education Seminar and the use of the e-assessment web by giving scores to each question: 4 for very agree, 3 for agree, 2 for less agree, and 1 for disagree. Table 3 showed the recapitulation of questions total in each peace in the questionnaire.

There were 25 respondents (students) fil-

ling the questionnaire. 14 students stated “very agree” and 10 students said “agree” in question number 18 which was the feedback given by the lecturer could motivate students to repair their assignments. Direct feedback on e-assessment web system influenced the quality of assignments submitted by students especially in sharpening their scientific communication skill. It was supported by Ruskanda (2015) who stated that giving feedback on online time kit web-influenced positively to improve students’ interpersonal skill. In question number 13, which was the use of e-assessment to submit students’ tasks and their assessment, was responded positively by 13 students by saying “agree.” They suggested that the use of e-assessment should make students download the assignments without seeing the lecturer in time work. By uploading assignments via online, students no longer printed them and cost less money and paper. Using computer could save half operational cost compared to using printed paper as counted by Miskiyah (2014) who developed the program of assessment simulation on a computer. Miskiyah (2014) further explained the benefits of computer assessment: 1) ease teachers in giving a score; 2) ease teachers in correcting the assignments. The percentage of positive responses by students towards assignment and assessment in Science Education Seminar was (84,43%)  $\geq$  81,25% categorized as “very good” which meant that the use of e-assessment in Science Education Seminar had fulfilled the criteria of product effectiveness. It was in agreement with Bollen et al., (2015) who said that developed digital assessment got positive responses from students and Rahimi et al., (2015) who explained that the use of web could help students construct their assignments and smooth the communication with the lecturer.

### Revising product

Revising this product was done if in the real condition there were deficiency and redundancy. In big scale test, the product was still revised especially its deficiency. Based on the result of observation, students had understood how to use e-assessment web well starting from login to seeing the assessment and feedback given after they did and uploaded the assignments of Science Education Seminar. The weaknesses found was the absence of the timer in uploading the assignments so that the students could still upload even though the deadline was over.

### CONCLUSION

Alternative assessment to measure scienti-

fic communication skill in Science Education Seminar course fulfilled the criteria of “appropriate” to be used with scores from assessment expert towards four assessments of Science Education Seminar: 94,64%, 92,86%; 91,07%; dan 92,86%. E-assessment web program was very appropriate to use with a score from information system expert: 90,63%.

The percentage of students’ positive responses was 84,43% categorized as very good. It showed that e-assessment program was effective to use because it had fulfilled the effectiveness criteria with good responses from students.

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## PROBLEM SOLVING APPROACH IN ELECTRICAL ENERGY AND POWER ON STUDENTS AS PHYSICS TEACHER CANDIDATES

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### ABSTRACT

In agreement with students' conceptual understanding, identifying of problem solving is an important part of physics. This article is to identify the approach used by students in solving a physics problem. The subject of the research were students of physics education year 2014 in Jambi University who had joined basic physics class. The instruments used in this research were DIRECT (determining and interpreting resistive electric circuit concept test) (Engelhardt & Beichner, 2004). Based on the result, 34,1% students still used the memory based approach in problem solving, 52,3% of them used no clear approach, 4,5% used structured manner, 6,82% used unstructured manner and only 2,27% students used a scientific approach to solving the problem. The result showed that many students used no clear approach and memory based approach to solve the problem. It mean that they did not use physics concept in solving the problem and generally they only used the equation they memorized related to the problem they ever did before.

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**Keywords:** problem solving approach; power and electrical energy; DIRECT

### INTRODUCTION

Students' problem solving ability in physics has become the focus in some recent researches in the last decades. Although problem solving is one of the categories of thinking ability that used by teachers to teach their students to think (Rufaida & Sujiono, 2013), the practice of problem solving is the main factor in science education and technology (Ceberio, et al., 2016; Ibrahim & Rebello, 2012), especially in physics education (Adam & Wieman, 2005; Docktor & Mestre, 2014; Docktor et al., 2010). A good problem solving framework was needed to build physics knowledge or introduce science culture (Docktor et al., 2016). Students attitude towards learning and problem solving in science and their conception

towards the purpose of learning science could give a significant effect on what they are learning (Mason & Singh, 2016). Problem solving is very important part in scientific reasoning because the skills in problem solving gives effect to change and improve emotional, cognitive and psychomotor improvement (Alshamali & Daher, 2016).

Modern cognitive science defines problem solving as a process to reach the goal when the way to it is unclear (Ryan et al., 2016; Docktor et al., 2016; Docktor & Heller, 2009). In physics education problem solving is usually used to understand physics and exact strategy to prove students' achievement (Docktor et al., 2016; Ceberio et al., 2016; Adams & Wieman, 2015; Ibrahim & Rebello, 2012). Besides, a good problem solving skills could help students transfer their knowledge and understand the physical situation (Walsh et al., 2007) because one of physics purposes is to

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know the physical situation (Galili & Guibarg, 2005).

When someone tries to solve a problem, they will make a model in their mind about how to solve that problem (Khasanah et al., 2016), because this model could improve students' ability to problem solving (Supriyanti et al., 2015). There are some ways used by students in problem solving. According to Docktor et al. (2015), there are two approaches used by students in problem solving; explicit problem solving and traditional problem solving. Students using explicit problem solving usually solve the problem by focusing on it, describing physics concept that will be applied, planning solution, finishing plan and evaluating solution, whereas students using traditional problem solving will start from drawing sketch, defining a known and unknown variable, choosing equation, and correcting the answer. According to Walsh et al. (2007) students were tended to solve the problem using four ways, they are a scientific approach, plug and chug (structured manner and unstructured manner), memory based approach and no clear approach.

In general, according to Walsh et al. (2007), students solving problem using scientific approach start solving problem by evaluating physical situation by focusing on seen physics concept, whereas students using plug and chug are divided into two group, students who solve evaluate problem by determining kind of formula that they will use in problem solving as well as known structured manner approach and students who concentrate only on identifying variable needed as well as known unstructured manner approach. Besides those approaches, there are two kinds of approach in problem solving; they are memory based approach and no clear approach. Students who solved the problem with memory based approach usually analyze the problem based on the situation they found in the past and try to remember the equation they used or similar problem they ever did before. Whereas students using no clear approach will solve the problem not based on the related concept and certain method, in which they are tended to manipulate variable given randomly to give the answer.

In previous researches, many students at Senior High School and University have faced difficulties in solving a physics problem, especially when they are facing a complex problem (Sujarwanto et al., 2014). Some researches results showed that although students could solve qualitative problem by inputting quantity to the equation (Rosengrant, 2009; Walsh et al., 2007; Redish, 2005) or they did not find difficulty in using

mathematics and formula (Ceberio et al., 2016), they did not build their skill by applying concept so they faced difficulties in solving more complex problem (Rosengrant, 2009; Walsh et al., 2007; Redish, 2005). Besides, most university students solve the problem by using traditional procedure, those students novice than expert procedure (Ryan et al., 2016; Caberio et al., 2016).

The students' lack in problem solving is due to their less attention to problem solving, in addition, they have a weak understanding of physics concept and law (Ceberia et al., 2016). In the learning process, the strategy which only focuses on how to solve a problem that needs mathematics calculation has become the cause of students' lack problem solving skill (Sujarwanto et al., 2014). Besides, many students also do not get well about the process in problem solving during learning (Brown et al., 2016).

In certain material like power and electrical energy, students have to understand the concept of power conservation which is the statement of second Kirchoff law in solving problem. According to Serway & Jewett (2004), in some books there are some mistakes which say that dissipated power in resistor which shows its energy disappears. The power does not disappear, but it changes into internal energy connected to atomic vibrations in the resistor. Misunderstanding the concept is also the main cause of students' lack ability in problem solving.

Some researchers in physics education have conducted research towards students problem solving skill by looking at how expert and novice attitude in solving a physics problem. Expert usually organizes their understanding about basic physics principle and decide to choose the relevant principle which help their to solve the problem (Docktor et al., 2016; Docktor & Mestre, 2014), whereas novice solves problem by taking their understanding, and will decide to do simple context based on the formula (Docktor et al., 2016). An expert will describe again the problem, and they often uses qualitative arguments to explain the solution before elaborating mathematically (Sujarwanto et al., 2014; Hull et al., 2013), evaluates the solution and use representation (Sujarwanto et al., 2014). Novice solve the problem by determining the formula and mostly faces difficulty (Hull et al., 2013; Walsh et al., 2007). Experts organize their understanding in a very structured manner and enable to explain when needed. Whereas novices do not use structured manner, their understanding is based on random fact and equation which are very little (Walsh et al., 2007).

The research about problem solving skill following by expert and novice attitude has often been conducted, but there is small amount the research about approach used by students in problem solving has been conducted especially in power and electrical energy. Indeed, the approach of solving problem used by students can influence their success on solving physics problem (Balta et al., 2016) and affect significantly to what they have learned (Singh & Mason, 2009; Mason & Singh, 2010). In this article, we would discuss the approach used by students in solving problem limited to power and electrical energy material, which is based on 5 problem solving levels, those are scientific approach, plug and chug (structured manner & unstructured manner) memory based approach, no clear approach.

### METHODS

Subjects in this research were students  $S_1$  of physics education at Jambi University who had joined basic physics class. One of the topics discussed in the class was power and electrical energy concepts. Based on the curriculum used in Natural Science Department, study programme

of physics education at Jambi University, power and electrical energy is discussed in basic physics class which is part of electrical dynamic material.

The respondents were 44 students who were divided into 3 class during the learning process. They were taught by two lecturers. During the learning process, the lecturers used some media such as PhET interactive simulations, moving animation, video and other strategies relevant with their own ways of teaching. The analysis approach used by students were based on the explanation of their answers adapted with indicators of problem solving approach level showed in Table 1. Each students' answers were grouped and adapted to the kind of problem solving approach they used. The data in this research were collected through the test. The instrument used were multiple choices with open ended questions referring to DIRECT (Determining and Interpreting Resistive Electric Circuit Concept Test) (Engelhardt & Beichner, 2004). DIRECT were developed to evaluate the conceptual understanding of Senior High School and first year university students about electricity (Engelhardt & Beichner, 2004). DIRECT consist of 29 multiple choices question, but in this research, the researcher only

**Table 1.** Indicators of Assessment Level in Problem Solving Approach

Level of problem solving approach	Indicators
<i>Scientific approach</i>	<ul style="list-style-type: none"> <li>• Analyzing physical situation qualitatively and referring to involved physics concept.</li> <li>• Planning and finding solution in a systematic manner based on the analysis</li> <li>• Focusing on concept in the process of problem solving</li> <li>• Evaluating solution</li> </ul>
Plug and chug	
Structured manner	<ul style="list-style-type: none"> <li>• Analyzing qualitative situation based on the formula</li> <li>• Planning solution based on the variables and systematic procedure</li> <li>• Referring to the concept of problem solving</li> <li>• Evaluating solution</li> </ul>
Unstructured manner	<ul style="list-style-type: none"> <li>• Analyzing situation based on seen variable</li> <li>• Starting by choosing formula based on variables in trial and error system</li> <li>• Referring to the concept as variable</li> <li>• Not evaluating solution</li> </ul>
Memory based approach	<ul style="list-style-type: none"> <li>• Analyzing problem based on the situation they have experienced before</li> <li>• The procedure is started by matching variable given with the example they have already faced</li> <li>• Referring concept as variable</li> <li>• Not evaluating solution</li> </ul>
No clear approach	<ul style="list-style-type: none"> <li>• Analyzing situation based on the given variable</li> <li>• The procedure is started by using variable in random ways</li> <li>• Applying variable as a term</li> <li>• Not evaluating solution</li> </ul>

(Walsh et al., 2007)

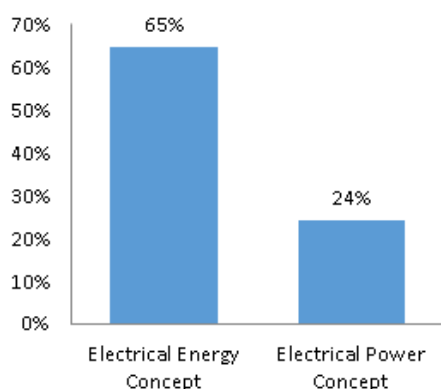


focused on some questions adapted with a research focus. Besides, in answering multiple choice, the students were asked to give their explanation, reasons of their answers based on the physics concept that they knew. It was to know what kind of approach they used in problem solving.

## RESULTS AND DISCUSSION

There are two forms in applying power and electrical energy tested to reveal the kind of approaches used by students. The first form was given in the context of two electrical series where one of them was arranged with a battery and a resistor while the other was arranged with a battery and two resistors in series. The second form was given in the context of three electrical series arranged with an energy source, which is a battery, in different ways. To solve these problems well, students needed to have the understanding of the following concepts: (1) Ohm law; (2) concept of current in series and parallel; (3) applying Kirchoff law about current and voltage; and (4) conservation law of charge and energy.

The percentage of students answering correctly in each concept of power and electrical energy, based on figure 1, from 44 students, 65% of them answered correctly whereas for electrical power only 24% students could answer correctly.



**Figure 1.** The Percentage of Students Answering Correctly In Power And Electrical Energy Concept

But, being seen from the approach used by students in explaining their answers, based on table 2, it showed that they were tended to use no clear approach mostly, there were 23 from 44 students or about 52,3%, the second order after it was memory based approach, it was 15 students or about 34,1%, and it was only one student or 2,27% who could apply scientific approach in solving problem concept of power and electrical

energy. The rests, 11,32% students used to plug and chug approach in solving the problem which consisted of structured and unstructured manners.

**Table 2.** Category of Problem Solving Approach (N = 44)

The level of problem solving approaches	The percentage of approaches used by students (%)
Scientific approach	2,27
Plug and Chug	
• Structured manner	4,5
• Unstructured manner	6,82
Memory based approach	34,1
No Clear Approach	52,3

If the result was adjusted with the assessment indicators of problem solving approach in table 1, it showed that very few students who applied the scientific approach to problem solving. It cause by the students tended to focus on variable and mathematical equation they knew and had experienced before while solving the problem without involving the physical situation and concept. This finding was in agreement with Docktor et al., (2010) & Jonassen et al. (2006) that showed students often solved the problem based on the numeric statement and finished it by determining the equation they knew and adopted it to the numeric statement. However, to succeed in problem solving students should know the problem, understand the relevant concept and know how the process to get the answer (Sabella & Redish, 2007; Jonassen et al., 2006) or apply the concept in a certain condition of the problem (Docktor & Mestre, 2014). Besides, learning process could be considered as a success if students could reach basic competences in problem solving like being able to think based on the relevant physics concept, able to make the representation, and able to interpret the physical description into the equation (Hull et al., 2013). It is done to the fact that problem solving is a strategy which is not only filled with knowledge but also technique and procedure (Halim et al., 2016).

This result was relevant to the research finding by Ceberio et al., (2016) & Walsh et al., (2007), that most students did not find difficulty in applying mathematic equation during problem solving, but they could not develop their skills needed to transfer knowledge and complex prob-

lem solving. In addition, students did not build their skills by applying the concept to problem solving, so they found difficulties in solve more complex problem (Rosengrant, 2009; Walsh et al., 2007; Redish, 2005).

Students understanding on was the topic which was being done taught or could they connect the material with the problem influenced the approaches used by students in problem solving (Kohl & Finkelstein, 2006). Students structure of knowledge and the problem character could also influence problem solving process (Sujarwanto et al., 2014). Besides that, the students' understanding, their experience with the topic, and how they were taught to solve the problem during learning process also could influence the kind of approach they used (Ibrahim & Rebello, 2012). Another factor was students' weakness in app-

lying mathematics into the process of problem solving (Tuminaro & Redish, 2004).

The answer in Figure 3a above showed how one of 44 students solved the concept of electrical energy if three circuits were set into three different circuits (Figure 2). The explanation was the example of the only student who applied the concept in problem solving, which was a scientific approach. To get the answer, the student tried to describe the situation qualitatively by explaining the form of the circuit and solved the problem by referring to the concept. Besides, he also searched the solution with systematic ways. It was in agreement with Walsh et al., (2007)'s statement, that student who uses a scientific approach to solving the problem will start by analyzing physical situation qualitatively, referring to the concept and applying systematical ways based

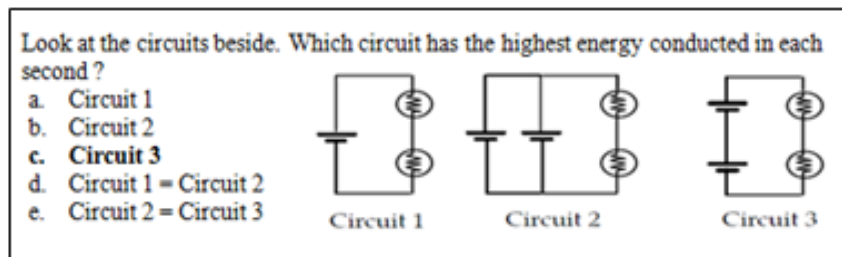


Figure 2. Question to know the level of understanding and problem solving skill about power and electrical energy

a) Pada rangkaian 1 terdapat hambatan yang tersusun secara seri secara seri yang mengakibatkan hambatan semakin besar dan tegangannya (sumber) satu. Jadi  $V = I \cdot 2R$   
 $I = \frac{2R}{V}$   
 $E = I \cdot R$   
 $E = \frac{2R \cdot R}{V}$   
 $E_1 = \frac{2R^2}{V}$

b) Pada rangkaian 2 terdapat 2 tegangan yang disusun paralel dan hambatan yang tersusun seri sehingga tegangannya adalah  $V/2$  dan nilai hambatannya seri ( $2R$ ) sehingga  
 $V = I \cdot R$   $E = I \cdot R$   
 $I = \frac{2R}{V/2}$   $E_2 = \frac{4R \cdot R}{V} = \frac{4R^2}{V}$

c) Pada rangkaian ketiga terdapat 2 tegangan yang tersusun secara seri, dan hambatan yang tersusun secara seri jadi  $2V$  dan  $2R$   
 $V = I \cdot R$   $E = I \cdot R$   
 $I = \frac{2V}{2R}$   $= \frac{1}{2} \cdot \frac{2R}{R}$   
 $I = \frac{V}{R}$   $= V$

Jika dimisalkan hambatan =  $2R$  dan tegangan  $4V$  maka energi terbesar adalah  $E$ . Rangkaian 2 = Rangkaian 3

(a)

Rangkaian yang memiliki energi terbesar yaitu Rangkaian 2 = Rangkaian 3 karena dari gambar dapat dilihat bahwa nilai tegangannya besar dan dimana Rumus  $W = q \cdot V$  (e). Rangkaian 2 = Rangkaian 3.

(b)

Figure 3. Examples of Students Answers (a) Applying Scientific Approach and (b) Applying No Clear Approach

on the analysis. The process of qualitative analysis like making a description, figure and graph to support the process of problem solving (Kohl & Finkeilstein, 2005). The application of qualitative analysis in problem solving process could improve students' achievement in explaining and predicting phenomena (Mualem & Eylon, 2007). In addition, a student who is expert in using conceptual reason during problem solving shows that he uses scientific approach (Hull., et al., 2013).

The answer in figure 3a showed that there were a mathematic mistake and students' formula in problem solving, especially when he counted the amount of source energy if the circuit was set in paralel and the formula of electrical energy used was not quite correct. Those mistakes did not omit the existence that the student used a scientific approach, because according to Walsh et al., (2007), a student who uses scientific approach can make mathematic and conceptual mistakes, but what is important is that he focuses on finding a solution with physics concept that they believes to be right.

Compared to 23 of 44 students or 52,3% who applied no clear approach to problem solving, which was the most approach used by students, it proved that they did not use qualitative analysis and concept in solving the problem. The example of student's answer in figure 3b, with the same problem as in figure 2, showed that the student solved the problem only based on the variable given and tried to used the equation he could possibly solve the problem. He did not analyze the situation of three circuits given in the question, so they made a mistake in determining the answer. This result was relevant to what was said by Walsh et al. (2007), that the focus of student using this approach was not on the concept but on the known variable. Applying many approaches without concept could be effective in finding the answer, but it is weak in the conceptual understanding during the solution process (Docktor et al., 2015). Furthermore, conceptual understanding and its application are some things important to know in problem solving (Sabella & Redish, 2007). As the opposite, the ability to problem solving was also a method to understand the concept, because according to Usmeldi (2016), the cause why students less understand the concepts is their lack ability in problem solving, science process, thinking, and reasoning. Not to mention, students who use no clear approach often make a mistake in the answer and easily change the approach to problem solving (Walsh et al., 2007).

An interesting finding in this study was a student who could use a scientific approach to

solving problem characterized that he followed expert attitude in problem solving. The similarities of expert person in problem solving and a person who was able to use scientific approach were: 1) every step of problem solving was always started with analyzing physical situation qualitatively and based on the concept (Hull et al., 2013; Rosengrant et al., 2009; Ogilvie, 2009; Kohl & Finkeilsten, 2008; Walsh et al., 2007), 2) the problem was solved with systematic and structured ways (Hull et al., 2013; Walsh et al., 2007), 3) always evaluate the solution (Rosengrant *et al.*, 2009; Walsh et al., 2007). Whereas students who used memory based approach and no clear approach tend to solve the problem characterized that they were a novice. The similarities between person used memory based approach and no clear approach and novice were: 1) every step was always based on the given variable (Hull et al., 2013; Rosengrant et al., 2009; Ogilvie, 2009; Kohl & Finkeilsten, 2008; Walsh et al., 2007), 2) they found the difficulties if the were given more complex problem (Rosengrant et al., 2009; Walsh et al., 2007).

## CONCLUSION

Based on the result and discussion above, it could be concluded that students tend to use no clear approach and memory based approach in solving the concept of power and electrical energy. It shows that most students do not solve the problem by analyzing the physical situation and applying physics concept to get the answer, but they only refer to the involved variable, random methods, and memorizing the same problem they have ever faced before. In addition, only a few students who could apply the scientific approach in solving the problem. It is caused by the lack of concepts belonging to students about power and electrical energy.

Based on these findings, during the learning process, it is suggested to apply a learning model which could help students to use a scientific approach. It is because that student who could apply scientific approach characterizes that he know the concept and has a good problem solving skill.

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## EFFECTIVENESS OF CRITICAL THINKING INDICATOR-BASED MODULE IN EMPOWERING STUDENT'S LEARNING OUTCOME IN RESPIRATORY SYSTEM STUDY MATERIAL

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### ABSTRACT

Research and development are aiming to develop critical thinking skills-based modules on the respiration system materials to empower the learning outcomes; verify the effectiveness of critical thinking skills-based modules with teaching materials in schools based on student learning outcomes. Research and development method are using Borg & Gall development procedure with nine phases. Data analysis that used for the research and development are qualitative and quantitative descriptive. Research and development results show that critical thinking skills-based modules on the respiration system materials were developed according to the indicators of critical thinking skills and knowledge dimension that visualised on the objectives, materials, activities and evaluation questions which are developed to empower the learning outcomes. The result of module effectiveness test, showed by Anacova test result are  $F_{\text{Count}} = 180,4$  on factual, conceptual, procedural learning outcomes which are visualised in the form of multiple choice questions and  $F_{\text{Count}} = 40.2$  metacognitive learning results are visualised in the form of essays.

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**Keywords:** critical thinking indicators-based modules; knowledge dimension; respiration system; learning outcome

### INTRODUCTION

The development in 21 century needs human resources which have quality and adaptation capability to face the changes of the times (Widhy, 2013). As an impact, everyone needs skills. Skills that needed are life skills and career, skills in technology, media and information, also innovation and critical thinking skills (Ledward & Hirata, 2011).

Critical thinking is a capability to consider any information from any sources and then processing in a creative and logic way, also analysing until it was concluded if that is correct and can

be maintained (Moon, 2008). Critical thinking is thinking seriously, active, accurate in analysing all of the information which has been received with a rational reason; therefore, every action that taken is correct (Liberna, 2011). Critical thinking is used to make an assessment of the information, explain the reasons and solve the problem (Thomas, 2011). Critical thinking has an important role in making the right decisions to resolve problems during the study or in daily life (Snyder & Snyder, 2008).

Critical thinking can be trained in formal schools through the interaction between teachers and students which is visualised in the learning process (Nafi'ah & Prasetyo, 2015; Thompson, 2011). Learning process which is designed to

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train students to think critically; therefore that students have a purpose to survive and compete in real life (Nusarastriya, Sapriya & Wahab, 2013). The learning process which is integrated with critical thinking trained through all subjects in high school, and also biology. Characteristic of biology is requires a distinctiveness in thinking, and this makes it possible to train critical thinking skills to enhance the concepts of biology (Nuryani, 2005).

Critical thinking in learning biology is developed one through literature because literature is a kind of text types that capable to empowering critical ideas (Khatib & Alizadeh, 2012). The literature which accommodates critical thinking does not promote about rote learning content, but to focus on the learning process (Lunenburg, 2011). Literature that accommodates critical thinking skills can be either as a book or modules.

A module which is containing critical thinking components, those are interpretation, analysis, conclusions, evaluation, explanation and self-regulation are called as critical thinking skills-based module (Fascione, 2011). Critical thinking skills-based module can be developed through several ways including: through open-ended questions, conceptual questions and Socratic questions (Redhana & Liliyasi, 2008). Open ended question is the ability to observe the activities of student's thinking in using their knowledge and then applied in daily life (Soeyono, 2013). Conceptual question is used to help students begin the process of solving problems and guide students to master the learned concepts (Redhana & Liliyasi, 2008). Socratic questions are critical questions that will help the students to develop ideas on the material which is being studied; therefore, the understanding of the subject becomes more profound (Redhana, 2012).

Critical thinking skills-based modules are developed in the respiratory system study material which earned by the survey by interviewing teachers, student questionnaire and analysis BSNP (BSNP, 2013). Modules or textbooks that used in high school on the Basic Competence of the respiratory system were analysed based on the contents of the module (objectives, materials, activities and evaluation questions) as well as the delivery and use.

The results of module analysis in the biology textbook 2 (Book I) and the biology textbook 2 (Book II), respectively obtained: 1) interpretation 38.2%; 32.9%, 2) analysis 30.7%; 23.9%, 3) inference of 26.2%; 26.2%, 4) evaluation 34.1%; 25.0%, 5) explanation 25.0%; 20.8%, and 6) of self correct 25.0%; 10.4%. Books or instructio-

nal materials which are indicators of the contents has not met the six indicators of critical thinking to the fullest necessarily fewer students' critical thinking activities optimally that will give impact to the lack of learning outcomes. Some studies show that students who have the low ability to think critically are tended to get lower learning outcomes if compared with the students who have high ability to think critically (Haseli & Rezai, 2013; Wulandari, Sjarkawi & Damris, 2011).

The results of delivery and application analysis in the book I and the book II are obtained: 1) interpretation 48.7%; 42.1%, 2) analysis 31.8%; 31.8%, 3) inference 40.5%; 26.2%, 4) evaluation 38.6%; 34.1%, 5) explanation 36.1%; 30.6% and 6) self correct 12.5%; 8.3%. Books or instructional materials which have delivery and application still not using the six indicators in critical thinking optimally will cause the lack of student's critical thinking activities, therefore, it's necessary to do more development. The solution is by developing critical thinking skills-based modules.

Module-based critical thinking skills on the material developed respiratory system aim to empower student learning outcomes in the four dimensions of knowledge that include: knowledge of factual, conceptual, procedural, and metacognitive (Anderson & Krathwohl, et al., 2010). Module-based critical thinking skills that developed are intended to encourage students to use critical thinking independently indicator and directional. Students who are accustomed to using critical thinking activities have logical thinking and rational and able to build their own critical thinking process through the activities in the module; therefore, it is expected to have a positive impact on student learning outcomes (Darmawan, 2010; Lunenburg, 2011). Yildirim & Ozkahraman (2011) suggested that student learning outcomes in high-level cognitive can be facilitated using critical thinking.

## METHOD

Methods of research and development using the Borg & Gall development procedures were modified in nine stages: 1) stages of research and collecting information, 2) planning stage, 3) development of early product stage, 4) stages of design validation, 5) main product revision stage, 6) limited field trial stage, 7) second product revision stage, 8) stages of operational field trials, 9) stages of the revision of the final product (Sugiyono, 2013)

Stage of operational field trial was conducted to determine the effectiveness of critical

thinking skills-based modules developed. Operational field trials using pretest-posttest design test Non-Equivalent Control Group Design (Sugiyono, 2013). The design of operational field trial is using two classes, namely control classes and treatment classes. Operational field subject is class XI IPA SMAN 3 Boyolali. Grades used were two classes of grade XI. The class consists of classes with teaching as usual (existing learning) which XI-2 and grade the effectiveness of the test module (XI-4). Operational field data collection instruments in the form of multiple-choice test questions that represents the factual, conceptual and procedural learning outcomes also essay test that represents the metacognitive learning outcomes in the respiratory systems study material. Metacognitive learning outcomes assessed using the rubric of cognitive and rubrics MAI (Corebima, 2009). Data analysis used anacova preceded prerequisite test sample that is the test of normality and homogeneity test. Statistical analysis programs assisted by SPSS 18 for windows (Yamin & Kurniawan, 2009).

## RESULT AND DISCUSSION

The results of the research and development of critical thinking skills-based modules to empower student learning outcomes are consists of:

### The results of research and collecting information stage

The results of the needs analysis in this study using critical thinking indicator based instruments and knowledge dimension in respiratory system study materials. The results of the analysis of contents in the book I show the highest average indicator is the interpretation of 38.2% and the lowest average indicators as well as self-regulation is an explanation of 25.0%. The results of the analysis of the delivery and application of books in the book I show the highest average indicator is the interpretation of 48.7% and the lowest average indicators are setting themselves up to 12.5%. The results of the analysis of the delivery and application of the book II shows the highest average indicator is the interpretation by 42.1% and the low average is the best indicator of self-regulation of 8.3%.

### The results of planning stage

The results of the planning stage is to analyze the interaction between indicators of critical thinking with the knowledge dimension indicators and adjusted on the basis of competence res-

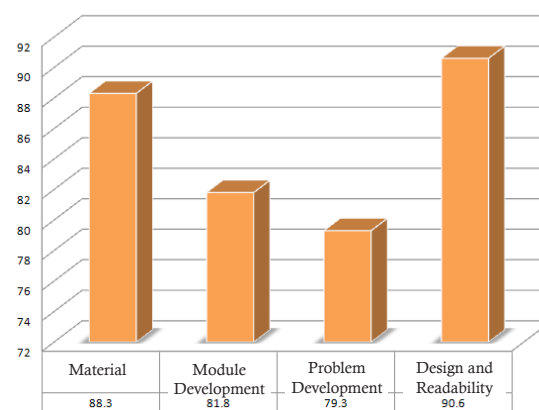
piratory system outlined in the matrix, to develop indicators of learning, determining a learning tool for the implementation of the module and determine the procedures related to the development of the module.

### The results of early product development stage

The results of early product development stage in the form of modules based on the material's ability to think critically respiratory system to empower student learning outcomes. Critical thinking skills-based modules in the learning objectives, materials, activities and evaluation questions are the development of indicators of learning that includes critical thinking indicators and indicators of knowledge in the material dimension of the respiratory system. Module-based indicators of critical thinking skills developed include confirmation book module (module teacher).

### The result of design validation stage

The results of the design validation stage as in Figure 1



**Figure 1.** Histogram of Percentage Rate Validation by Experts

Figure 1 shows that the validity of the material, the characteristics of the module, about the characteristics and the design and readability of the early product of critical thinking skills-based modules in respiratory system, is in conformity with the target, as shown by the results of expert validation of material gain value 88.3%, showing a good qualifying, expert validation module development to get the value of 81.8% indicates good qualification, validation expert development a matter of getting the value of 79.3% indicates a good qualification and validation of design experts and legibility get the value of 90.6% indicates excellent qualifications.

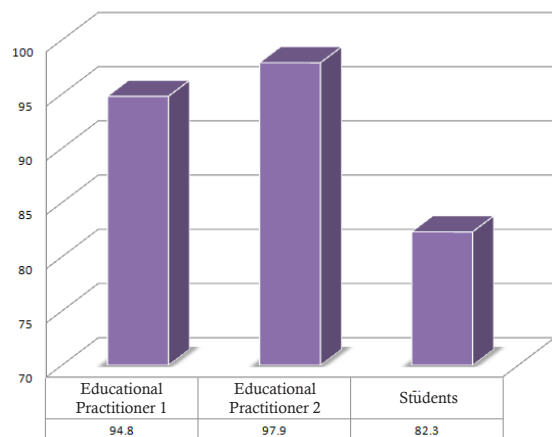


### The results of main product revision

The result of main product revision stage which made based on suggestions and revisions of the validation of materials experts, module development experts, development specialists and the design experts.

### The result of limited field trial stage

The result of limited field trial stage is obtained results as in Figure 2



**Figure 2.** Histogram of assessment in Limited Field Trial

Figure 2 limited field trial of education practitioners and small groups of users concluded that the critical thinking skills-based modules on the respiratory system materials get value 94.8% and 97.9%, showing excellent qualifications based on ratings educational practitioners and scores 82.3 %, showing good qualification based assessment of small groups; therefore, it can proceed to the stage of operational field trials to determine the effectiveness of the module after fixing the shortcomings of the education practitioners and small groups of users.

### The results of second revision stage

The results of the second stage product revision are done based on suggestions and revisions from education practitioners are presented in Table 1 as well as a small group of test users in Table 2.

### The results of operational field trial stage

The results of operational field trials stage using Anacova is F count = 180.4 and a significance level of  $0.00 < 0.05$  on factual, conceptual, procedural, learning outcomes which is visualized in the form of multiple choice questions, as well as the F count = 40.2 and a significance level of  $0.00 < 0.05$  in metacognitive learning results are visualized in the form of essays. Anacova test

results showed a significant difference between the control classes that uses teaching materials grade school with treatment using critical thinking skills-based modules demonstrated the significance level of less than 0.05. The difference between the control classes and the treatment classes showed that the modules based on the material's ability to think the critically respiratory system is more effective to empower the learning outcomes if compared with school teaching materials.

**Table 1.** Revision of Suggestion and Correction by Education Practitioners

Suggestion	Correction
Colour contrast of the image is created in every part of organ structure, therefore, it is obvious.	Replace the image more obvious in every part of the organ structure
Question to the student activity is much overlap; it should be combined; therefore, it does not overlap.	The questions in the activity have been integrated with the activities of the students, therefore, it does not overlap.
Margin limit of the module is needed to be trimming.	Margin limit has been trimmed.

**Table 2.** The Results of Suggestion Correction and Small Group User Revision

Suggestion	Correction
It is recommended to use the clear explanation to ease students' understanding	Difficult language should be changed by general terms; such as affinity to be binding. The terms used must be explained by a glossary.
The purpose of learning must be described.	Learning outcome is not described as already described in general to materials, activities and problems.
It is recommended to simplify the study material.	The material has not simplified because it explains the learning objectives.
It is better to use the general terms instead of Latin language.	The use of Latin language has a purpose of acquainting the students to Latin terms to improve the students' knowledge.

**The results of final product revision stage**

The result of the revision stage of the final product from critical thinking skills- based modules gained from qualitative information and results of the analysis of operational field test stage in order to obtain proper modules are used. The results of the operational field test stage known that nothing needs to be revised; therefore, the final product revision is not done.

The development of critical thinking skills-based modules on the study material discussed on the respiratory system is about: the development of critical thinking skills-based modules on the respiratory system study materials, the feasibility critical thinking skills-based modules and effectiveness critical thinking skills-based modules on the respiratory system study materials.

**Development of critical thinking skills-based modules on the respiratory system study materials**

Critical thinking skills-based modules on the respiratory system study materials is a module that developed according to the model development procedure Borg & Gall which has been modified into nine stages (Sugiyono, 2013). The module aims to trained critical thinking skills that will impact on increasing learning outcomes. Module-based critical thinking skills are developed based on the analysis of textbooks used in the schools.

Critical thinking skills-based modules on the respiratory system study materials were developed based on indicators of critical thinking and knowledge dimension. Indicators of critical thinking and knowledge dimension outlined in the matrix are visualised in the form of indicators. Indicators developed in the form of objectives, materials, activities, and about the evaluation of the module in the sub-subject of the respiratory system are arranged in a systematic, operational and directional (Mulyasa, 2005).

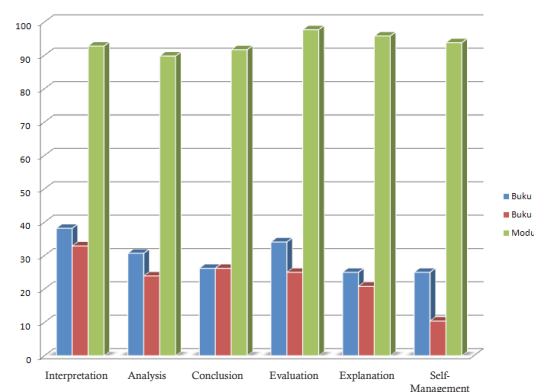
Products of critical thinking skills- based modules developed has advantages compared with the teaching materials in schools, because it is based on content analysis module which includes objectives, materials, activities and evaluation questions based modules critical thinking skills obtain a higher percentage as described in Table 3 and presented in Figure 3.

Table 3 shows that the indicators on the critical thinking critical thinking skills-based module more than in the teaching materials in schools. In the book I found in the smallest increase of 54.6 interpretation indicators and the biggest increase in the indicator explanation contained 70.8;

59.1 followed by analysis indicators; conclusions indicator amounted to 65.5; evaluation indicators amounted to 63.6 and 68.8 indicators of self-regulation. In book II smallest increase contained in the interpretation of indicator reached 59.9 and the biggest increase self-regulation contained in the indicator amounted to 83.4 followed indicator analysis of 65.9; conclusions indicator amounted to 65.5; evaluation indicators of 72.7 and 75.0 for the explanation.

**Table 3.** Histogram of Comparison of Compliance on Critical Thinking Indicators by module

Critical Thinking Indicators	Comparison of Module Component Percentage (%)	
	School Teaching Materials	Module of Critical Thinking
<b>Book I</b>		
Interpretation	38.2	92.8
Analysis	30.7	89.8
Conclusion	26.2	91.7
Evaluation	34.1	97.7
Explanation	25.0	95.8
Self-Regulation	25.0	93.8
<b>Book II</b>		
Interpretation	32.9	92.8
Analysis	23.9	89.8
Conclusion	26,2	91.7
Evaluation	25.0	97.7
Explanation	20.8	95.8
Self-Regulation	10.4	93.8



**Figure 3.** Histogram of Comparison of Compliance on Critical Thinking Indicators

Based on the content interpretation analysis of books I and II books are known have the

smallest increase. The small increase is due to the textbooks used in the schools own interpretation indicators despite the highest value are not optimal, more in Table 1 and Table 2. Indicators of the interpretation are the ability to understand, explain the meaning of a situation, experience, incident data and decisions (Widiyowati, 2015), which is usually found in many textbooks at school; therefore, the addition of the interpretation indicator is not as much as another indicator of critical thinking.

Analysis of Book I and II books experienced the largest increase in the explanation indicator and self-regulation. Explanations indicators and self-regulation in the book I get an average of the lowest indicators by 25%, whereas in the second book of self-regulation indicators earn on average 10.4%. The largest increase in the book I was an explanation indicator from 25% to 95.8%, the module is based on critical thinking skills to add an explanation indicator by 70.8%. Explanation indicator is not just a description but include explanations that related to a connecting descriptions process and logically relationships and using empirical data as the basis of explanation (Wu and Hsieh, 2006). The largest increase in book II is an indicator of self-regulation from 10.4% to 93.8% module is based on critical thinking skills to add indicators of self-regulation by 83.4%. Indicators of self-regulation (self-regulation) are to monitor a person's consciousness cognition process personally to ensure themselves are already involved in critical thinking activities or not (Ricketts & Rudd, 2004).

The indicators of critical thinking on critical thinking skills-based module indicate the success of research in improving teaching materials in schools are related to the fulfilment of the teaching materials to train critical thinking activities. Module-based critical thinking skills did not reach the percentage of 100%, because the indicator material is not all indicators derived from indicators of critical thinking and indicators of dimensions of knowledge can be visualized on the module as indicators of observing an experiment, identifying experiment, designing experiment, rewrite, create, prove, determine, analyze, evaluate, distinguish between the experimental results and summarize the results.

Module-based critical thinking skills is one form of literature reading with instruction activities focused on learning and not just focus on the content, developed with a variety of instructions and practices through technical questions that encourages students to analyze, shortly synthesis, and evaluate information to solve problems and

make decisions (Snyder & Snyder, 2008; Darmawan, 2010; Thomas, 2011). Module-based critical thinking skills not only developed on specific learning objectives, but also on indicators of the capacity to think (Kartimi & Liliyasi, 2012).

Feasibility of critical thinking skills-based modules in respiratory system has been tested through the steps of a) validation test by the experts includes: materials experts, module development experts, development specialists and experts about the design and legibility, more is presented in Figure 1; b) a limited field test consisting of an education practitioner and teacher by a small group of test users by students, more is presented in Figure 2.

Based on Figure 1, it shows that the results of the feasibility test on critical thinking skills-based modules based on the expert validation are qualified as good until very good. Qualifications were obtained from materials experts; module development and development experts about as well as excellent qualifications are shown by the expert design and readability.

Based on Figure 2 shows the average assessment by education practitioners acquires excellent qualifications and a small group of test users by students gain good qualifications. Based on the due diligence obtained from expert validation and limited field tests concluded that the module-based critical thinking skills in the respiratory system study materials fit for use because it has been through expert validation stage, the assessment of education practitioners and the small group of test users.

#### **The effectiveness of critical thinking skills based modules in the respiratory systems study material.**

The effectiveness of the module-based critical thinking skills on the material respiratory system to empower student learning outcomes, grouped into two, covering the learning outcomes of factual, conceptual and procedural uses multiple choice questions, and learning outcomes metacognitive uses essay (test metacognitive) (Anderson & Krathwohl, et al., 2010).

#### **Effectiveness in terms of factual, conceptual and procedural learning outcomes using Multiple Choice Questions (MCQs)**

MCQs represent the factual, conceptual and procedural learning outcomes which analysed using Anacova test and more at present in Table 4.

The results of student's learning using critical thinking skills-based modules are higher if

compared to the results of student learning using teaching materials in schools. The results of anacova test is a rejection decision of  $H_0$  for obtaining sig value of 0.00 ( $<0.05$ ). Parameter estimation results obtained results -29.13 (Trihendradi, 2013), which means that classes that do not use the module-based critical thinking skills score 29.13 posttests lower than the class that uses the think critically modules.

**Table 4.** Anacova test in multiple choice questions

Variable	Pre test Average	Post test Average	F	Sig	Partial Eta Squared
Control Classes	42.6	61.2			0.723
Treatment Classes	33.2	88.0	180.42	0.00 ( $<0.05$ )	Estimation parameter (-29.13)

The difference between the results of posttest in control classes and the treatment classes showed that the module based on the material's ability to think critically of the respiratory system is more effective in empowering learning outcomes on the dimensions of factual knowledge, conceptual and procedural. The results are supported by research Lunenburg (2011) that indicators of critical thinking are contained in learning, one module contributes to the achievement of student learning outcomes. Rosana (2014) adds that students with critical thinking skills are tend to get higher learning results if compared with students who have the ability to think critically low, since students who have the ability to think critically high use thought to feed on comprehending the material well, analysing and able to solve their problems.

#### Effectiveness of student's metacognition skills using essay questions

Metacognition test using essay questions that were analysed by Anacova and more served in Table 5.

Table 5 shows that the learning outcomes of students who use critical thinking skills-based modules higher than the results of student learning using teaching materials in schools.

**Table 5.** Anacova test in metacognitive questions

Variable	Pre test Average	Post test Average	F	Sig	Partial Eta Squared
Control Classes	45.1	58.2			0.368
Treatment Classes	39.1	68,7	40.18	0.00 ( $<0.05$ )	Estimation parameter (-10.72)

The results of Anacova test is a rejection decision of  $H_0$  for obtaining sig value of 0.00 ( $<0.05$ ). Estimation parameter results obtained results -10.72 (Trihendradi, 2013), which means that classes that do not use the module-based critical thinking skills score 10.72 posttests lower than the class that uses the modules of think critically.

The difference between the results of posttest in control group and the treatment classes showed that the modules based on the material's ability to think critically respiratory system are effective in empowering learning outcomes on the dimensions of metacognitive knowledge. The results obtained are supported Kusumaningias, Zubaidah & Indriwati (2013) which suggests that critical thinking in learning is able to empower metacognitive skills that aim to form students become independent learners (self-regulated). Critical thinking which contains in the module helps students to develop their metacognitive skills, argue, self-confidence, have independence in learning and scientific honesty (Murtadho, 2013).

#### Effectiveness of critical thinking skills-based modules in learning outcomes

Critical thinking skills-based modules are generally more effective than teaching materials in schools in empowering learning results because it has a purpose and a clear material, valid evaluation questions and activities are more targeted because it is using critical thinking indicator and knowledge dimension indicator. Critical thinking skills-based modules have some variants of learning activity which equipped with the supporting questions to improve the critical thinking skills. Learning activities are summarised in the module that consists of a practicum, simulation, observation, self-reformation and administration issues. Learning activities and questions in the compiled modules are interrelated and organized. It supports to have a deep understanding (Johnson,



2009).

Indicator in thinking critically that trained by the use of module are potential to supports in thinking empowering because the six indicators are cognitive skills which able to accommodate the students' cognitive development (Yildirim dan Ozkahraman, 2011). Cognitive skills that empowered through critical thinking activities in the module, helps students to gain an increase in learning, because students who are trained as critical thinkers are capable of working on all high-level thinking on the cognitive processes dimensions (Mandernach *et al.*, 2009; Thomas, 2011). Students who have good critical thinking skills are expected to have an understanding, confidence and a new perspective that potential to have good learning outcomes.

### CONCLUSION

The conclusion of the research and development are critical thinking skills-based modules in respiration system material was developed according to the indicators of critical thinking skills and knowledge dimension that visualised on the objectives, materials, activities and evaluation questions. Feasibility of the module which obtained by the expert's validation are shown good qualifications until very good; based on education practitioners are showing excellent qualifications and based on a small group of users test show good qualification. Effectiveness of the module was shown by the results of Anacova test which obtained F count = 180.4 on factual, conceptual and procedural learning outcomes which represented by Multiple choice question and F count = 40.2 metacognitive learning outcomes which represented by essay, stating there are significant differences between the results of students which using critical thinking skills-based modules on learning with teaching materials in schools; therefore, that the critical thinking skills-based module are more effective than teaching materials in schools.

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## DESIGN AND IMPLEMENTATION OF SCHOOLY-BASED BLENDED LEARNING MEDIA FOR BASIC PHYSICS I COURSE

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### ABSTRACT

This research was conducted to: (1) design a Schoology-based blended learning media for Basic Physics I course on the topics of vector quantity, linear motion, and translational dynamics, (2) describe the validity of the product, (3) describe the product's effectiveness in enhancing students' conceptual understanding and problem solving skills, and (4) describe students' responses towards the media and blended learning model. The development procedures employed were ADDIE model which consisted of five stages: analysis, design, development, implementation, and evaluation. In development stage, the assessment had been conducted by two experts to assess validity of media both in content and construct aspects. The results showed that the validities in content aspect and construct aspect were "very good" and "good", respectively. The results from classroom implementation revealed the effectiveness of the product in enhancing students' conceptual understanding and problem solving skills. Students' responses towards the product's utility, attractiveness, and easiness as blended learning media were also positive. The conclusion was that the media was valid and effective as blended learning media of Basic Physics I course.

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**Keywords:** basic physics i; blended learning (BL); schoology

### INTRODUCTION

Facing the rapid development of globalization era in the 21<sup>st</sup> Century, teachers and educational institutions are demanded to be able to prepare their students to have competences or skills. Problem-solving skill, effective communication skill, decision making skill, collaborating skill, information literacy, information and communication technology (ICT) literacy are parts of the 21<sup>st</sup>-Century competencies (Binkley, et al., 2012). As a consequence, teachers should design learning activity which could fulfill the demands of those competencies. One of the ways is through integrating ICT with learning process to train students about information literacy and ICT literacy. In

fact, integrating ICT in Basic Physics I course at Physics Education Program University of Lampung is still poor. ICT especially the internet is only used as a source to look for learning materials and questions. On the other hand, the lecturer often feels the limited time for face-to-face meeting since this course covers extent topics. Because of limited time, most assignments given to the students were usually without feedback.

Meanwhile, from the survey about students' internet access, it is known that 90% of 59 students have internet access through laptop, PC or mobile phone. At campus, wifi access is also free. The students who do not have their internet access stated they could access it through internet cafes around the place they live. However, more than half students stated that the speed is not fast enough. The survey showed that the internet ac-

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cess of students supports to integrate internet in learning process.

One of the forms in integrating internet in learning process is e-learning. Implementing e-learning in science learning by using problem-based learning model could improve students ICT literature (Eliana et al., 2016). Similar with e-learning, another integration is blended learning (BL). BL or also known as hybrid learning is a learning model which combines various presentation model at class with online learning (asynchronous and synchronous) (Wu et al., 2010). Graham (2006) more specifically stated that BL is a kind of learning model which combines two different learning environment: face-to-face meeting and online learning.

Some research showed that BL had many advantages like increasing flexibility (Pratt & Trewern, 2011), increasing effectiveness and students' motivation (Barbour & Reeves, 2009), growing students' independence in learning (Parkes et al., 2011), and improving students' ICT skill (O'Dwyer et al., 2007). Compared to the pure face-to-face learning or pure e-learning/online learning, BL is said to be more effective (Means et al., 2009) students joining BL model have better performance than those following traditional learning method (Yapici & Akbayin, 2012). The same result also reported by Poon (2013) who compared BL class with traditional classroom. The result was the class given BL method has higher test score than the class using the traditional method. A research by Kazu & Demirkol (2014) also found that students using BL method have higher average scores than those using traditional learning method.

The use of BL could stimulate students to be more active, creative, and independent in looking for information needed so they could learn independently and understand the concept well. The use of BL also could repair some weaknesses from conventional learning method, one of them is the lack of time in face-to-face meeting. Online learning could be used as an addition to improve students' understanding of the material who has not been explained by the lecturer in class. Besides adding knowledge, features from online learning also make students more enthusiastic and interested in learning since they could access many sources via online.

BL types that are usually implemented are online – face-to-face and face-to-face – online. In the former type, students follow online learning first before face-to-face meeting so that each student has the same initial understanding (Smart, 2006). Face-to-face session is usually used for

detail explanation and problem-solving (Smart, 2006) or to extend students' understanding and connect the concept to the further area (Collopy & Arnold, 2009). Whereas in face-to-face – online, the materials are given in face-to-face session then the students are asked to discuss and think critically via online (Aycock et al., 2002). Michinov & Michinov (2008) also supported this kind of BL to deliver togetherness (a sense of community) among students. Another purpose is to help students be familiar with the online class structure.

The two types of BL have their own benefits. BL does not have a standard type (Aycock et al., 2002). It was also emphasized by Helms (2014) who stated that there may be differences in the best way to schedule a course based on the discipline, course content, and other concerns". By the reason to have the benefits of both BL types, in this study the researchers used the format of online – face-to-face – online. The first online learning would be used to give initial understanding to students whereas the second online learning would be used to discuss concept application on the certain topic.

Nowadays, many applications could be used to create online learning freely. Those applications are called Learning Management System (LMS). LMS web based is referred to facilitate an access towards learning material and administrator anytime and anywhere (Black et al., 2007). The use of LMS brings good advantages for students or teachers. From the view of students, the advantage is in the increase of control they have wherever and whenever they involve in the learning process. From the view of teachers, the benefits are very structured tasks management, efficient, and safe (Fadde & Vu, 2014), and could grow students' critical thinking through discussion forum (Comer & Lenaghan, 2013).

One of LMS which has the basic version available freely and easy to use because it is similar to social media like Facebook is Schoology. The menu which Schoology has are Courses, it is a facility to create one course, Group, which is a facility to create community learning, and Resources, which is a facility to save learning material. In Courses menu, there is quiz menu which has many kinds such as multiple choice, true-false, matching, and short answer. Making questions in Schoology is equipped with tools Symbol and Equation. All questions with Figure, symbol, and equation could be written on Schoology. Besides, schoology has many features and an interesting layout like online assessment book, attendance list, the reminder of feature user from students



(Nugroho, 2015). Other benefits that Schoology has are mobile access, integration with Google Drive, tools to make content, and access to the library, etc. (Medved, 2016).

Based on the explanation above, this study was conducted to develop a product which is technology based BL in basic physics I course with main materials vector, straight motion, and translation dynamics. The developed BL media included handout, material for online discussion, and online questions uploaded in Schoology online class. Not to mention, this study also described the validity of BL content and construct based on expert assessment, the effectiveness in improving concept understanding and students' problem-solving skill, and students' responses towards its benefit, its attractiveness, its ease and its class model.

## METHOD

The study was conducted from March to October 2016 in Physics Education Program, Faculty of Teacher Training and Education, University of Lampung. This study referred to development model of ADDIE (analysis, design, development, implementation, and evaluation) (Peterson, 2003). ADDIE model as firstly used in the 1990s had a function as a reference in developing learning set and infrastructure which were effective, dynamic, and supportive (Sumarti et al., 2015).

In analysis stage, the researchers did literature study, field survey, and need analysis. A literature study was done to get information related to BL model and previous relevant studies results. A field survey was done to get the information of supportive facilities belonging to students. In the design stage, the researchers made BL media draft including handout, online discussion questions, online tests. In the development stage, the expert validated to assess the content appropriateness and product construct. In implementation stage, the product was implemented in limited class to test its effectiveness; the test used one shot case study design.

BL type used was "online learning – face to face – online learning" in every week (Figure 1). In every week, face to face class was done once to discuss the main topics. There were three main topics; they were the vector, straight motion, and translation dynamic. Before face to face meeting was done, the students joined online learning, and they also joined online learning after face to face meeting.

Online learning before and after face to

face meeting was done with discussion method. The students were given two to four problems to discuss with their classmates through lecturer guidance. Online discussion was done asynchronously, in which the students did not discuss at the same time, but it depended on their availability. Online discussion forum on Technology was organized so that students could answer first before using, reviewing, or studying their friends' answer.

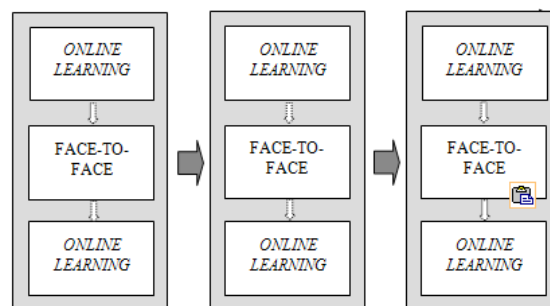


Figure 1. BL type used in the study

The data included expert validation from questionnaire, concept understanding data, and problem-solving skill taken the test, and students' responses taken from the questionnaire. Validation questionnaire was Likert scale with four responses, starting from 1 (invalid) to 4 (very valid). Students' responses questionnaire were also in Likert scale with five choices, from 1 (very disagree) to 5 (very agree). The instrument of understanding concept used was short essay questions consisting of 15 numbers with the allocation time 30 minutes whereas the instrument of problem-solving essay questions consisting of 6 numbers with time allocation 75 minutes. Students' responses questionnaire and two instrument tests were validated by the experts of content aspect and instrument construct.

All data taken were analyzed quantitatively and descriptively. The criteria of classification in experts validation data and students' responses were shown in Table 1. If the expert assessment showed product validity with category "good" the learning process could be continued in the next stages.

## RESULT AND DISCUSSION

BL media produced were Syllabus and Lesson plan, handout, discussion topic before face to face meeting, and online tests with main topics of the vector, straight motion, and translation dynamics. All those materials were uploaded on online Schoology made with Courses featu-

**Table 1.** Data classification of experts validation and students' responses

Average score of validity	Category	Average score of responses	Category
3.26 – 4.00	Very Good	4.20 – 5.00	Very Agree
2.51 – 3.25	Good	3.41 – 4.20	Agree
1.76 – 2.50	Less Good	2,61 – 3,40	Doubt
1.00 – 1.75	Not Good	1.81 – 2.60	Disagree
-	-	1.00 – 1.80	Very Disagree

re. The layout of the online class could be seen in Figure 2. Every folder contained: 1) handout, made with *Add File/Link/External Tool* features; 2) discussion forum before and after face to face meeting, with *Add Discussion* feature; and 3) independent test, with *Add Test/quiz* feature.

Meanwhile, the example of the learning process with BL model for vector topics shown in Table 2. Online activity before face to face meeting was used to discuss sub material whereas online activity after face to face meeting was meant to discuss sub material that could not be finished during face to face class and give applied tests to finish some problem.

The produced handout contained material explanation for each discussion topics. The handout was written with emphasizing basic concepts as the reference of the usual textbook. Discussion material on face to face meeting contained questions about the problem related to the brief material of each discussion topics. Those questions were meant to improve students' understanding of each topic. Discussion material on face to face meeting was made to facilitate an online class in the last part of each discussion topics. The contain included concept application, last part of the discussion topic that could not be finished at face to face class, and wider explanation. The emphasize of discussion after face to face meeting focused on students' problem-solving skill. Question test was meant to facilitate students to do interactive exercise independently so that their understanding improved. The questions were made in multiple-choice by giving feedback in every wrong answer.

### Product Validity

The product assessed by some experts included handout, online discussion material, and online question test. The assessment of product validity done by an expert of Physics Education and an expert in education technology showed that the validity of product content had 3,48 in average with the category "very good" and the validity of construction aspect had 3,21 in average with category "good." In conclusion, the deve-

loped media could be said relevant to the purpose of development and appropriate to used in BL of Basic Physics I course.

With experts' assessment, the product was then revised by their suggestions. The suggestions given for handout revision were adding material explanation related to the similarity and the difference in vector, consistency in using terms on vector or scale such as distance, position, speed, and motion. In online discussion material, the suggestions were simplifying unclear questions and describing problem illustration. The suggestions related to online test were the consistency of feedback in directing students to answer correctly and adding the questions about problem-solving.

### Product Effectiveness

After revision, the product was then implemented in class with topics of the vector, straight motion, and translation dynamics for three weeks in the course of Basic Physics I. In the fourth week, the test was done to measure students' concept understanding and problem-solving skill. The data related to students' concept understanding and problem-solving skill were shown in Table 3.

By using minimum achievement (MA) score 66 (B as the minimum category at Lampung University undergraduate program), the percentage of students reaching MA was 80,6% for concept understanding aspect and 74,2% for problem-solving skill. Since the percentage of MA was greater than 70%, the product could be said effective as learning BL media on Schoology in the course of Basic Physics I.

### Students' Responses

At the end of the learning process, students were asked to answer questionnaires related to their responses towards the benefit, attractiveness, and ease of BL model with Schoology. There were 31 students responding. The result could be seen in Table 4. In general, students gave positive responses related to the developed media and BL model class in Basic Physics I course.

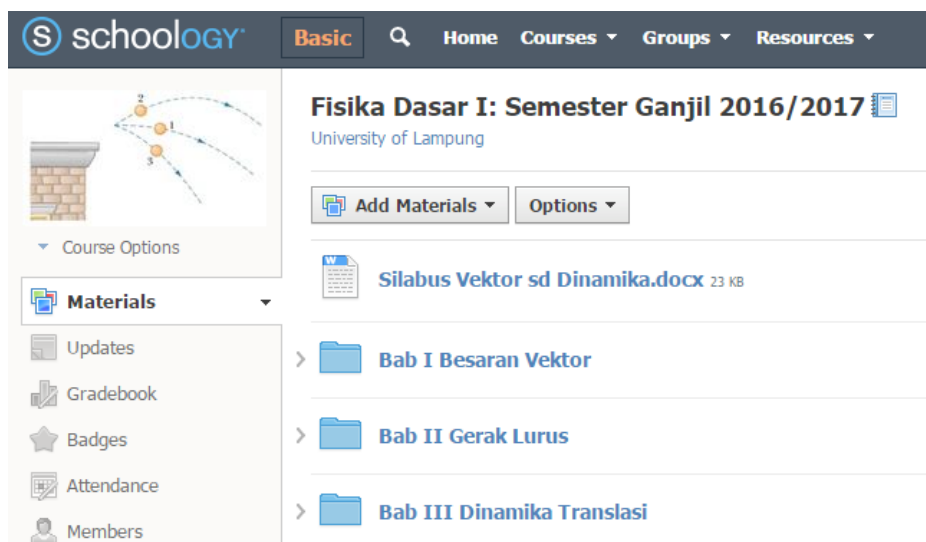


Figure 2. The layout of online class

Table 2. Learning activity sample in BL model with the topic of vector

Standard Competence	Material	Learning Activity	Mode
Operating vector (addition, reduction, and product) with various methods	Vector sub material:	Discuss the definition of vector, unit vector symbol, vector representation in graphic, vector component, and the similarity of two or more vectors	Online
	Vector representation		
	Vector unit	Explain vector writing by using vector unit	Face to face
	Vector operation	Doing addition and reduction on vector by using graphic method and vector component method	Face to face
		Doing product on vector, including dot product and cross product	Online
		Training to do applied addition and product on vector in the context of physics problem	

Table 3. The data of concept understanding and problem-solving skill

Score	Concept Understanding		Problem Solving Skill	
	Total	Percentage	Total	Percentage
$\geq 76$	3	9.7	1	3.2
66 – 75	13	41.9	9	29.0
61 – 65	9	29.0	13	41.9
< 61	6	19.4	8	25.8
Total	31	100	31	100

**Table 4.** Students' responses related to media and BL model

Aspect	Score	Category
Benefit	3.85	Agree
Attractiveness	3.72	Agree
Easiness	3.31	Doubt
Average	3.63	Agree

Based on the table above, it was known that students' assessment towards product benefits and BL model class was considered to be useful. There were 8 items in the questionnaire related to the benefits; they were benefited for improving learning interest and motivation, understanding and problem-solving skill, and students' ICT skill. Besides, the students were also asked about their interest to join the next BL model class. The responses given on all question items were the "useful" category.

In similar with students' responses towards benefit, their responses towards attractiveness aspect were also good. In the questionnaire, there were 6 questions; these were about product attractiveness (handout, online class, online test), the attractiveness of online learning activity, and the attractiveness of BL model. Most students' responses towards each question were good, except for the question about the handout, they suggested that the attractiveness on handout was very good.

Different with two previous aspects, students' responses towards the easiness of BL model, in general, were in "doubt" category. They were not sure about the easiness in joining BL class. In the questionnaire, there were 7 questions, they were about the easiness in joining BL model class, the easiness in accessing the contain, the easiness in communicating via online, and the easiness in answering online test. The lowest response was on the easiness of online discussion. From the interview, the most problem faced was the slow internet connection and students' time management.

This research was conducted to produce a learning media that could improve students' experience and learning performance. Based on the implemented test in the class above, the purpose of this research could be said as a success. More than 70% of students reached the minimum standard 66 in both concept understanding and problem-solving skill aspects. It meant that the developed Blended Learning media could become alternative sources for students, they did not depend only on teachers/lecturers.

Through BL with online-face-to-face-

online format every week, students had more opportunity to interact with their lecturer and mates. Online discussion was done before and after face to face meeting. Face to face meeting was on Wednesday. Online class was done before it, Monday to Tuesday, and after it, Thursday to Saturday. Providing more opportunity to interact with students and lecturer was the main important factor to make a quality BL media (King & Cerrone, 2012). Through online discussion activity, students became more ready to join face to face meeting class (Aspden & Helm, 2004). It was thought to influence the performance of standard understanding and students' problem-solving skill.

Choosing online discussion could also influence students' activity in online learning. This online discussion was chosen because it gave more chances to students to search and write answers or opinions before presenting them in the discussion forum (Alim, 2007), and also make students stay interacting with the lecturer whenever they have time to Aspden & Helm, 2004). Also, based on the observation in class, the asynchronous online discussion also helped students who have limited internet connection. They could easily find the time when the internet access was fast. However, it' weakness was the lecturer needed a long time to gave feedback on their answers.

Providing handout and the online test could also improve students' concept understanding and problem-solving skill. By explaining the material in detail and providing answers of question examples, handout helped students learn course material. It was reflected in their responses towards questionnaire in which they evenly really agreed with handout attractiveness, related to online test; there were 15 multiple choice questions filled with feedback if their answers were wrong. With the existence of exercises that could be accessed many times, students were easier to learn course material. It was also reflected in their responses stating that online exercise could improve their understanding.

In line with product effectiveness, students also responded positively towards the developed product and BL model based in Basic Physics I course. Their responses indicated that learning with Bl model gave another benefit, it could improve their interest and motivation as it was said by Barbour & Reeves (2009), grow students' independent learning, as said by Parkes et al., (2011), and improve students' ICT skill, as stated by O'Dwyer et al., (2007).

The result of this research was relevant with previous researches about BL effectiveness.



Lim & Morris (2009) explained that traditional (face to face) class equipped with online material had the positive effect towards students' competencies. Applying BL was even more effective in improving their learning performance compared to face to face meeting only or fully online learning (Means et al., 2009). Kazu & Demirkol (2014), Poon (2013), Yapici & Akbayin (2012), and Uzun & Senturk (2010) researched revealing that the performance of students joining BL was greater than those following face to face meeting only.

Therefore, there were some obstacles faced during implementing Schoology based BL model at class. First was internet speed was not fast, so it became the main factor for students to join online learning. The second was students were difficult to write their answer containing mathematic equation, symbol or graphic, in Schoology discussion forum. Indeed there were symbol and equation tool facilities for students. But, they were not used to them, also, how to use them was different from Microsoft Office Word, the solution given by students was that they wrote their answers on paper and uploaded them on the discussion forum. Uploading and reviewing Figure answer took more time and needed fast internet access.

Other problems were the lack of students' activeness in discussing and their time management. In the discussion, they only gave the answer without asking or responding to others' answers. Indeed, in this research they were not asked to comment each other, they were only obligated to give their answers. Online discussion forum on Schoology could be set so that the students would send their answers before they could see, review, or learn each other answers. From the interview, there were two reasons why they seemed not to discuss with each other, first was they felt afraid, shame, or hesitate with their lecturer and mates. The second was they always met every day at the campus, so they felt easier and more comfortable to ask directly. About time management, most students tended to submit their answers on the late deadline. At the beginning of the discussion, some students even did not send their answer, and they also mistook the schedule.

Previous researchers had also stated problems found in this research. Kenney & Newcombe (2011) stated that some students wait for the last minutes to send and submit their answers on the discussion forum, submit tasks, sometimes they also face technical problem during online learning. From the researchers himself, the problem was more burdening work. Besides to design

and prepare learning sources took more time, preparing online discussion forum also need much time like stated by Kenney & Newcombe (2011). However, the students felt no meaningful learning burden in following BL model, as previous researchers explained it.

In this research, there were some limitations, not all facilities available in Schoology were used. The researcher did not use facilities like test or assignment (including project assignment) via online. It should be studied further, considering that in Indonesia online assessment is rarely done (Wijayanti & Basyar, 2016). Face to face meeting was also limited to lecture, discussion, and question session. This research also did not consider the quantity of BL media use by students, which could influence their learning performance (López-Pérez, 2011). Another limit in this research was the amount of topic discussion and time duration which was short. So, further research about this should be conducted.

## CONCLUSION

Based on the result and discussion, it could be concluded that it was produced Schoology based BL media in main materials vector, straight motion, and translation dynamic with the score of content validity 3.48 (very good), and the score of construction validity 3.21 (good) from the maximum score 4.00. From the result of implementation at class, it could be concluded that the BL media was effective to improve students' concept understanding and problem-solving skill where more than 70% students reached the standard minimal score. In general, the students also responded positively towards benefit, attractiveness, and easiness of NL media, with average score 3.63 from 5.00 as the maximum score.

About the result of this research, physics teachers especially should develop and apply blended learning at class. However, there were some problems found during the research like slow internet access, students' difficulty in writing answer containing mathematic equation, symbol, or graphic on Schoology forum, students' lack activeness during the online discussion, and needing much time to prepare online asynchronous discussion. So, it needs following researches related to field study in a bigger scale, developing BL for other courses, and optimizing other features on Schoology.

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## NATURAL SCIENCE BIG BOOK WITH BADUY LOCAL WISDOM BASE MEDIA DEVELOPMENT FOR ELEMENTARY SCHOOL

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### ABSTRACT

Big Book is an especially characterized storybook that being enlarged, both the text and the pictures and designed as interesting as possible so it could motivate the students in learning the lesson in school. Big Book media in this research was developed based on local wisdom in Baduy as the effort to introduce the local wisdom values in Baduy custom area, so it may grow the love towards the local custom. The benefit of using the local wisdom based Big Book is the teacher can easily interest the students to focus on the story that will be read and make it easier for the students in understanding the material because the contents of the material are related directly to the student's daily life. From the data that have been gathered, there are 79.7% to learning material expert validation and 83.41% to learning media validation. So, it can be concluded that Big Book media is appropriate to be used in the learning process.

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**Keywords:** baduy; big book; local wisdom; media

### INTRODUCTION

Education is a systematical process that happened all the time to lift prestige and dignity of the human being whole. It can be seen from the education philosophy, which is: (1) affective that reflected in the quality of faith, etiquette, aesthetic, and good moral and character.; (2) cognitive that reflected in thinking capacity and intellectuality to dig the knowledge and develop it and also mastering the technology; and (3) psychomotor that reflected in the ability to develop technical and practical skill (Depdiknas, 2006). As a whole thing all those philosophies rooted on how to prepare the students to be able to live their life well, so in this case, education become a strategic ride to develop the student's potentials.

The policy to increase the quality of edu-

cation is aimed at the achievement of education quality that determined by the government in National Education Standard (SNP). SNP include the component of a content standard, process standard, passing competence standard, educators and educational staff standard, infrastructure standard, management standard, financial standard, education scoring standard. The achievement of those standards is used as the base to do the scoring towards the performance of education unit and program, started from Early Childhood Education (PAUD), elementary school, middle school, non-formal school, to high school (Depdiknas, 2006).

In the elementary school, reading ability must be watched carefully. According to Dahlan & Rahma (2016), reading is one of the language skill besides writing, listening, and speaking. Reading is an active receptive activity where the reader will identify the symbols of the writing actively.

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Besides, reading has a very important social role in human life. First, reading is a communication tool which needed in a cultural society. Second, the reading material that resulted in every age in history mostly affected by developed language social background. Third, as far as the history ever recorded, reading has resulted in different social classes (Hartati, 2014).

Related to the reading skill in elementary school, reading lesson must be suited to the level according to the low and high class. For the low-class students, the reading phase is beginner reading. Beginner reading in low-class students is a foundation of quick reading, extensive reading, and understanding reading phase. To achieve that, the teachers must really sharpen the beginner reading skill students.

According to Tarigan (2008), reading is a process that done and used by the readers to get the message that the writer wanted to deliver by words media or writing language. Harjasujana, et al. (2003) stated that reading is a result of interaction between perceptions towards the symbols that represent the language through language skill that the readers have and their knowledge about their surroundings. Basically, reading is an activity to find the messages or information that wanted to be delivered by the writer through words media or writing.

Reading ability of elementary students in Indonesia is still categorized as low compared to the other countries. It can be seen in the result of PIRLS (Progress in International Reading Literacy Study) research that has been done by IEA (The International Association for The Evaluation of Educational Achievement) which stated that from 45 countries that become the samples of the research, Indonesia is sitting in the 41<sup>st</sup> (Litbang, 2013). The student's reading motivation can be stimulated by interesting learning media in the form of pictures or big text (Najiah, A., et al. 2016).

One of the causes of the low reading interest of Indonesian people is the low reading culture in Indonesia. The low reading skill in elementary students in Indonesia must be treated seriously. If a student cannot read well, then the student will face the difficulties in understanding the reading material. It surely will slow the reading activity and understand the material in the next phase and the other language aspects like writing.

Besides, Sukmawati (2016) stated that another problem in reading like letter introduction, words understanding, terms, reading structure introduction, interpretation towards reading the material, interpreting implicit mean in a rea-

ding material, and determining the main topic and the explanative topic in a paragraph.

Suyanto (2007) stated that there are some things that may help in reading lesson, which is: (1) using pictures as a helping tool; (2) giving questions; (3) shows the title and asked the students to guess it; and (4) the use of short sentences that will confuse the students. Those aspects must be fulfilled, so the student's reading ability will get better.

To fix the student's reading ability a learning media that may increase the student's reading interest. In elementary school learning process, media is very important. Media affected the interest of students to study. Media helps the teachers in delivering the material, so the students will understand the material easier.

Mahbub, et al. (2016) stated that learning is a tool to outline the learning process. While Association of Education Communication Technology (Mahnun, 2012), interpret media as all kind of forms that can be used in message delivering process.

Media is all kind of physical tools that used to deliver the content of the learning material. In this understanding, books/modules, tape recorder, cassettes, video recorder, camera video, television, radio, films, slides, photos, pictures, and computer are learning media (Taufiq, et al. 2014). It means media is related to the mediator that functioned to channel the messages and information from the source that will be received by the receiver of the messages that happened in the learning process.

One of the media that can increase the interest and reading skill of the students is Big Book. According to Suyanto (2007), Big Book is one of the media that liked by the children and can be easily made by the teachers. This big sized book usually used for low-class students and the contents are a short story with big text with colored pictures.

According to Puspaningrum (2015), Big Book has the excellence for its big size so it can handle the readability of the students in class. Next, Anggraeni (2016) stated that Big Book is an especially characterized storybook that being enlarged, both the text and the pictures, so it can make the reading together activity between the teacher and the students become possible. Big Book can be a reading media through reading together activity and also can be a good media in understanding reading because it can make the students work together in giving the means of the words in it.

According to Astari, et al. (2016), the use

of Big Book media will be very well done in indoor class activity. Big Book is a book that approximately sized 40x30cm with interesting colored pictures and large text, so it will be clear enough to be seen together by the children.

Big Book appearance must be able to grow the reading interest in students. Setiawati, et al. (2013), stated that children love to have stories and interesting, colorful pictures in their books. They seemed to not realize that they are studying while reading the story books. Story books are more interesting and easier to understand by the children.

Based on the research that has been done by Yuniati (2014) about the use of Big Book in elementary school in low class resulted in a conclusion that the use of Big Book may increase the student's activeness and increase the beginner reading ability in low-class students. So, the development of Big Book media is very good in order to increase the reading ability of low-class students.

Big Book not only pressed on reading skill and writing of the students but also developed a good behavior and character of the students. It gained from the mean and message that conducted in a story that written in Big Book. "The Big Book approach attempts not only to teach various reading strategies and concepts about print but also to impart them in a manner that is meaningful and interesting to the young learner" (Nambiar, 1993).

In the process of developing student's character, the learning material will be more if connected to the local wisdom. Local wisdom can be understood as a human's effort by using their thought to act towards something, object, or happening in a certain space. (Ridwan, 2007).

Local wisdom is a value of life that inherited from a generation to the next generation in religious, culture or custom form that normally shaped in spoken form in a social system of a society.

According to Thamrin (2013), local wisdom is a system in a social, politic, culture, economy, and environmental order that live in the middle of local society. The characteristic that always sticks in traditional wisdom is the dynamic characteristic, continuous, and can be accepted by its community.

While according to Fajarini (2014), local wisdom is a way of life, knowledge and also any living strategies that have been done by the local society in answering the problems in fulfilling their needs.

The existence of local wisdom is a result

of adaptation process in a very long time towards an environment that usually inhabited or where interactions often happened.

## METHODS

The method that used in this research is Research and Development (R&D). R&D method is a method that used to create a certain product and test the effectiveness of the product. (Sugiyono, 2009).

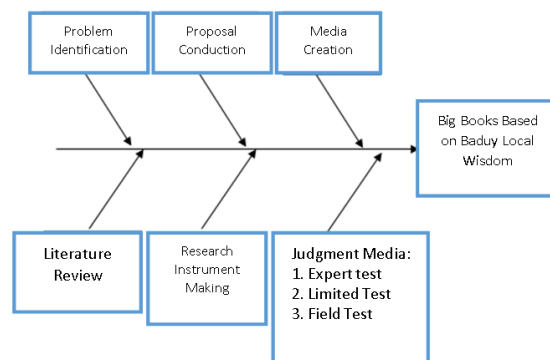


Figure 1. Steps of R&D Research

Steps in Media Judgment Process consisted of:

1. Expert test is a media decency scoring process that done by experts and practitioners in elementary school, so the media can be well used in the learning process in elementary school.
2. Limited Test is a test conducted in the student samples that will be tested with Big Book.

## RESULTS AND DISCUSSION

The result of the research of this learning media development has been done based on a development procedure in 4D (*four-D*) model that simplified to 3D (*three-D*) that has been determined in the previous chapter which is doing definition, designing, and developing.

### Description of Learning Media Making

#### Defining

From the result of the definition of natural science subject, the data was gathered in the form of curriculum and syllabus in fourth and fifth grade which is curriculum 2013 that will be used as a media development guide. Besides, media making device, media usage and natural science material that will be developed is also gotten.

Learning media that was created contained natural science subject material for the first

semester. It was done to suit the curriculum and syllabus in the elementary school with Baduy local wisdom material.

Based on the curriculum and syllabus of fourth grade in elementary school and the time implementation the basic competence that has been gotten are 3.7 Describing the relation between the natural source with the environment, technology, and society, 4.6 Serving the report about natural sources and its usage by the society. While the curriculum and syllabus of fifth-grade students, the basic competence are 2.2 Describe the dependency of human and animals to green plants as a food source and 3.2 Identify plant's self-adjustment with the certain environment to stay alive.

After the developed material has been determined then the next step is doing literature review and field study to gather the material and objects about the environment in Baduy society.

#### Designing

After getting the ingredients to create a learning media in defining phase, then the researcher designing Big Book with Baduy local wisdom base learning media.

#### Developing

The creation of Big Book with Baduy local wisdom base learning media was done manually, where every picture served in the content of this Big Book are self-created pictures by using crayon or color pencil. Then all pictures and narration text scanned, and the next phase is printing process on the A3 paper. After all the picture have been printed, then they were booked using the spiral ring.

In this phase, learning media that has been created is developed according to the desired Big Book with local custom media through product validation process. The validation process is done by material expert lecturers, media expert lecturers, and elementary teachers as the education experts.

Based on the learning experts' validation score data analysis criteria table the score is 139.5 in 35 points of the question. The average score is 3.985 with final percentage score as many as 79.7% included in "Appropriate" category.

Based on the learning experts' validation score data analysis criteria table the score is 171 in 41 points of the question. The average score is 4.17 with the final percentage score as many as 83.41% included in "very appropriate" category. So, it can be concluded that Big Book media is appropriate to be used is learning.

**Table 1.** The Result of Learning Material Expert Instrument Validation

Scoring Aspects	Validator I	Validator II	Average Score
Content Appropriateness	75	62	68.5
Serving Appropriateness	39	32	35.5
Contextual Scoring	37	34	35.5
Total	151	128	139.5
Average Score	4.31	3.66	3.98
Score Percentage %	86.3 %	73.2 %	79.7%

**Table 2.** The Result of Media Experts Instrument Validation

Scoring Aspects	Validator I	Validator II	Average Score
Graphic Appropriateness	114	136	125
Language Appropriateness	38	54	46
Total	152	190	171
Average Score	3.71	4.63	4.17
Score Percentage %	74.2 %	76 %	83.41%

From the result of media appropriateness test the researcher hopes that Big Book media can be one of the learning media alternatives that will motivate the students and impact the increase of student's study achievement especially in natural science lesson in elementary school, it is suitable for the research conducted by Handhika, J (2012) who stated that learning media basically increase the student's learning motivation and study achievement. Visual media in the form of pictures (Big Book, comic) have the function to increase the study result beside to increase the motivation, and it was already proved in research conducted by Fatimah & Widiyatmoko (2014) who showed the study result of the students that rise in the middle category.

## CONCLUSION

Based on the research question in Big Book media development with Baduy local wisdom base in a natural science subject, then it can be concluded that:

Big Book media with Baduy local wisdom

development in natural science subject based on 4D model development that has been adapted into 3D which are define, design, and development. The test was done in the students in fourth and fifth grade in elementary school. The media product that has been developed in this research is appropriate to be used in elementary school that apply curriculum 2013 because it is already fulfilling the product success indicators.

Big Book with Baduy local wisdom base media appropriateness in natural science subject for the fourth grader was gotten from the scoring result from material experts, media experts, and education experts. The score result of material experts is 3.98 in average with 79.7% included in "appropriate" category. The scoring result of media experts is 4.17 in average with 83.41% included in "very appropriate" category.

Based on the research result and Big Book with Baduy local wisdom base media development, the writer gives a suggestion which is Big Book with the Baduy local wisdom base media development product can be used as an alternative choice in natural science subject learning.

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## COMPUTER-BASED EXPERIMENT OF FREE FALL MOVEMENT TO IMPROVE THE GRAPHICAL LITERACY

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### ABSTRACT

The purpose of this study is to develop computer-based experiment of free fall movement to improve the graphical literacy of the Physics Education students. This study employed quasi-experimental design, particularly the pre-test and post-test control group design. The sample was 58 students of the first semester of Physics Education study program. They were divided into two groups, namely 38 students constituted an experimental group and 20 students constituted the control group. Both groups joined learning activities at laboratory and classrooms with the same topic which is the free fall movement. Computer-based learning models were used to design learning activities for the experimental group, while the control group used a traditional learning model with manual experiment with stopwatch and never use experiment tool of free fall movement. It was indicated in this study that the use of such learning model improved the graphical literacy capability better than the traditional learning, which covered ability to identify experimental variables, using the experimental tools, making a graph, formulating mathematical equation, making predictions on the basis of the graph.

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**Keywords:** physics education; computer-based experiment; graphical literacy; laboratory activity

### INTRODUCTION

On the subject of Basic Physics 1, there is a topic about the movement kinematics of free fall movement. The measurement model of the free fall experiment has used traditional method since years, namely by using a stopwatch to measure the time of an object to fall from certain height. There is now a research which has successfully developed a set of microcontroller-based free fall movement experiment with a PC display. The result of the tool development has created the tool which can measure the acceleration of the earth gravity accurately, which is 98.3% (Dasriyani et al. 2014). The review of the research suggested that the tool only showed the graph of  $g$  value,

without any feature to show the graph equipped with the other parameters such as the influence of mass, object shape, and height as an effort to improve the students understanding towards the concept of free fall movement (Dasriyani et al. 2014). The recent study of computer-based learning of free fall motion had been shown that coupling real life phenomenon with computer modeling in free fall motion can help the students' understanding the concept (Wee et al. 2015). Therefore, further, development is needed to produce a computer-based free fall movement tool to improve the graphical literacy.

In a pre-test of movement kinematics, we found that most of the students had not understood the concept of free fall movement well (Bambang, 2012). For instance, (1) when an object falls from a certain height, the mass and sha-

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pe of the object affect the falling time; (2) when two objects with the same mass and shape fall from a different height, it gives a different value of the earth gravity acceleration. Learning these empirical facts, we are interested in developing a computer-based learning strategy of free fall movement to delve the graphical literacy capability. In order to ease the explanation of free fall movement concept for the students, we need to teach the procedure and process of making the graph first.

In order to support the activities in kinematics learning which develop the graphical literacy, several learning models should be combined (Bambang, et al. 2015a). It is because the learning process of free fall movement starts from the problem that the students get from the lecture and then it is continued by solving the problem through activities in the laboratory. When the students create a graph, they need a kind of software to present data in a graphic and to interpret it. Thus, in this research, we used multiple model instructions to teach the computer-based free fall movement to delve their graphical literacy.

Graphical literacy is a construction which describes the ability to understand the information presented in the form of a graph (Okan, et al. 2012). The Programme for International Student Assessment (PISA) 2013 set the graphical literacy capability in the situation and context within PISA framework (PISA, 2013). This phenomenon is important since PISA has been a parameter of education success in a country. Thus, students of primary education should have been taught about the graphical literacy and the future teachers. Therefore, they should also have a provision about graphical literacy. Through the graphical literacy capability, the students are capable of interpreting the graph. The students need to understand how to analyze data and how to draw a conclusion from a graph.

Some lecturers have used the graph to explain concepts in their class, but they have not explicitly taught the way of this visual communication (Colemen, et al. 2011) The low understanding towards the graphical literacy of the students will affect their understanding towards kinematics concepts. They are teacher candidates who have to master the graph interpretation and have to explain to their future students about it in both oral or written. Based on the early limited finding of graphical literacy capability of students in bachelor degree and master degree of Physics Education study program in Bandung, it shows that: (1) 46% of students of bachelor degree and master degree in Physics education still have difficulties

in making graph, (2) the students' capability in interpreting graph is very low which is only 13% (Bambang, 2012; Sharma, 2005 & Sutopo, 2013).

Various efforts have been conducted by the previous researches to identify and to overcome the students' difficulties related to the graphical literacy. The research found that the ability to interpret graph is influenced by the characteristics of the graph, for instance, the form, type, content, and the initial knowledge about the graph (Glazer, 2011). Similar researches suggest that understanding graph is influenced by their data interpretation context (Roth and Bowen, 2003). For instance, the students' understanding towards the content affects the ability to analyze and to describe the data. The next research found that the students were difficult to read, to interpret, and to understand the information presented in a graph (Didem, et al. 2012; Sezen et al. 2012; Uzun et al. 2014).

Based on the review of these results, we have not found any research concerned to improve graphical literacy through computer-based learning strategy of free fall movement. Thus, we dedicate this research to do so. The research problems are: how is the learning strategy in free fall movement material to delve the student's graphical literacy and equipped by supporting facilities? while the research purpose is to produce computer-based learning strategy of free fall movement to delve the graphical literacy capability of the students.

## METHODS

This research used quasi-experimental design which was the pre-test and post-test control group design, as shown in Table 1. The sample of this research was 58 students of the first semester of Physics Education study program. It consisted of two groups, namely 38 students constituted the experiment group and 20 students constituted the control group. Both groups joined learning activities at laboratory and classrooms with the same material which was the free fall movement. The experiment group used a computer-based experiment tool of free fall movement; while the control group used a manual one which was the stopwatch as an experiment tool of free fall movement.

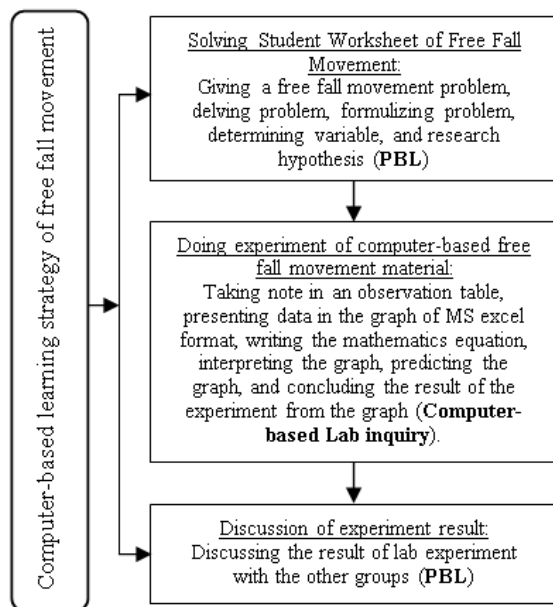
The instruments used test and non test. The test was used to measure the students' concept understanding before and after the learning process, while the non test instrument was an observation sheet to measure the experiment activity of free fall movement.

**Table 1.** Pre test and post test control group research design

Groups	Pre test	Treatment	Posttest
Experiment	O1	X	O2
Control	O2	-	O2

**RESULTS AND DISCUSSION**

The learning strategy developed in this research is multiple models instruction. The learning strategy resulted here is the elaboration of problem-based learning model, laboratory inquiry, and computer-based learning as shown in Figure 1.



**Figure 1.** Computer-based learning strategy of free fall movement

The learning procedures of the computer-based learning strategy of free fall movement are as follow:

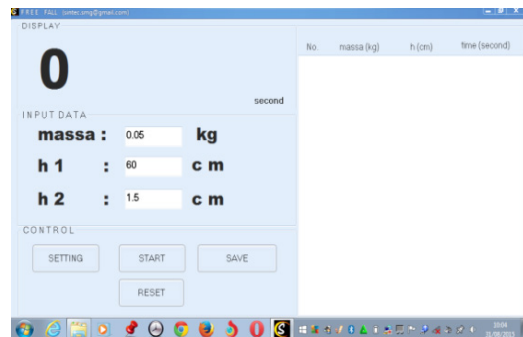
Students are given a worksheet. They have to read and learn the problems given in the worksheet, to formulate the problem, to determine the research variable, and to construct a hypothesis.

Students do a laboratory experiment to solve the free fall movement. The computer-based learning strategy is as follows: students construct the experiment device of computer-based free fall movement and setting the device as shown in Figure 2.



**Figure 2.** Setting the computer-based device of free fall movement.

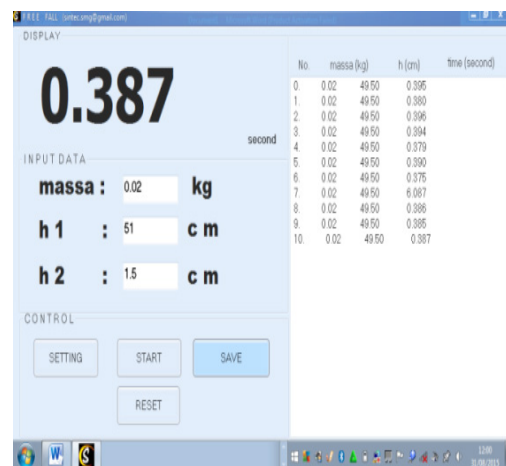
Inputting the data (mass, height) and setting the USB port.



**Figure 3.** Display interface of the computer-based experiment of free fall movement

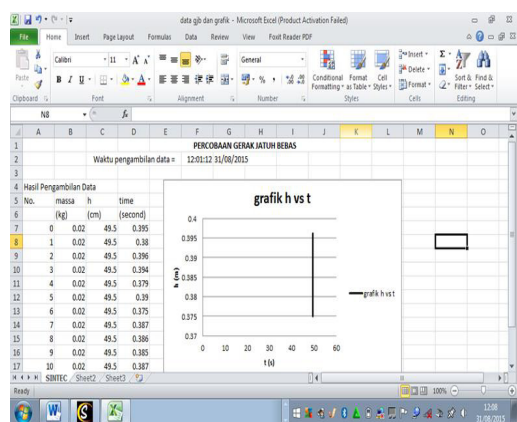
Dropping objects with a variation of mass, shape, and height in minimum 10 times.

This step was done in order to get the relationship between mass, shape, and height with the gravity acceleration. The students use any things they have in their pencil case as a dropping object. The data were presented in Figure 4.



**Figure 4.** Display of the experiment result of the computer-based free fall movement

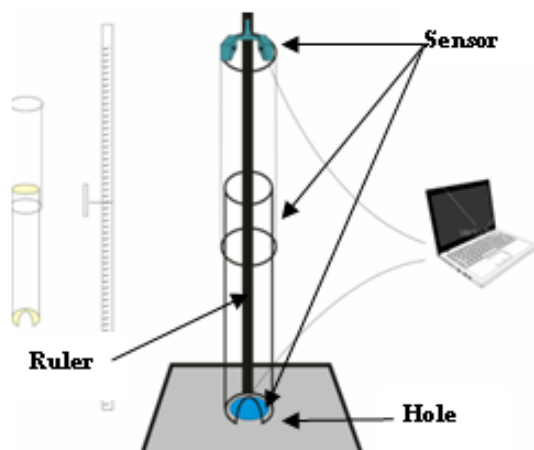
Saving the experiment data by clicking Save, and then checking the data display in the form of MS Excel and graph, and then presenting the data in the form of a graph.



**Figure 5.** Data display of the experiment in MS Excel display

Writing a report, presenting the observation data in Ms. Excel graph, writing the mathematics equation, interpreting the graph, predicting the graph, and concluding the experiment result based on the graph display.

Designing the device of free fall movement. Below is the illustration of experiment tool design of free fall movement which is computer based and equipped with a sensor.



**Figure 6.** The sample of a design result of the student's experiment of computer-based free fall movement.

The activities measured in this learning process are: (1) the students' ability to formulate research questions based on the fact directly observed from the free fall movement device, (2) identifying research variable, (3) operating

the device, (4) reading the measurement result, (5) making graph variation, (6) formulating the mathematics equation, (7) interpreting the graph, (8) predicting the graph, (9) concluding the result of experiment, and (10) designing the innovative device of free fall movement. The working assessment rubrics to measure the learning activities of the computer-based experiment of free fall movement is as shown in Table 2.

**Table 2.** Rubrics of the computer-based experiment of free fall movement to improve the students' graphycal literacy.

#### Activities and Description Score

Formulating research questions based on the fact directly observed from the free fall movement device.

Description of the score:

1. Unable to formulate research questions based on the fact directly observed from the free fall movement device.
2. Able to formulate research questions but the questions are not focused on the fact directly observed from the free fall movement device.
3. Able to formulate research questions based on the fact directly observed from the free fall movement device.

Identifying research variable (dependent variable, independent variable, and control variable), and formulizing hypothesis.

Description of the score:

1. Unable to identify research variable (dependent variable, independent variable, and control variable), and unable to formulate hypothesis correctly.
2. Able to identify research variable (dependent variable, independent variable, and control variable), but unable to formulate hypothesis correctly.
3. Able to identify research variable (dependent variable, independent variable, and control variable), and able to formulate hypothesis correctly.



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 Activities and Description Score
 

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Operating the device to test the hypothesis.

Description score:

1. Unable to operate the device to test the hypothesis well and correctly, so they always need help from the lecturer or the other groups.
  2. Able to operate the device to test the hypothesis well and correctly, though they sometimes need help from the lecturer or the other groups.
  3. Able to operate the device to test the hypothesis well and correctly without help from the lecturer or the other groups.
- 

The ability to collect data from the measurement.

Description score:

1. Unable to collect data completely based on the purpose of the measurement.
  2. Only able to collect some of the data based on the purpose of the measurement.
  3. Able to collect data completely based on the purpose of the measurement.
- 

The ability to make a graph.

Description score:

1. Unable to create a graph, *unable* to write the scale of the axis, label, and unit correctly.
  2. Able to create a graph not in the smooth way though the axis scale, label, and unit have been written correctly.
  3. Able to create a graph in a smooth way, the axis scale, label, and unit have also been written correctly.
- 

The ability to formulate the mathematics equation from a graph.

Description score:

1. Unable to formulate the mathematics equation based on the graph created.
  2. Able to formulate the mathematics equation based on the graph created though it is not correct.
  3. Able to formulate the mathematics equation based on the graph created.
- 

The ability to interpret the graph.

Description score:

1. Unable and there is no effort shown to interpret the graph correctly.
  2. There is an effort to interpret the graph though the interpretation is not correct.
  3. Able to interpret the graph correctly.
- 

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 Activities and Description Score
 

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The ability to predict the graph.

Description score:

1. Unable and there is no effort shown to predict the graph correctly.
  2. There is an effort to predict the graph though the prediction is not correct.
  3. Able to predict the graph correctly.
- 

The ability to conclude the experiment result according to the graph.

Description score:

1. Unable and there is no effort shown to conclude the experiment result based on the experiment purpose and the graph created.
  2. There is an effort to conclude the experiment result, though it is not suitable for the experiment purpose and the graph created.
  3. Able to conclude the experiment result based on the experiment purpose and the graph created.
- 

The ability to design the device of free fall movement.

Description score:

1. Unable to design the device of free fall movement.
  2. There is an effort to design the device of free fall movement, though it is a lack of innovation.
  3. Able to design the device of free fall movement with high innovation and creativity.
- 

Based on the collection score collected for the pre and post test from experiment and control group results are shown in Table 3.

**Table 3.** The students' graphical literacy

	Pre-test		Post-test		N-gain	
	Exp	Ctrl	Exp	Ctrl	Exp	Ctrl
N	38	20	38	20	-	-
Mean	66.7	58.4	90.3	84.1	0.7	0.6
SD	15.6	20.1	9.9	8.7	-	-
Std. Error Mean	2.5	4.5	1.60	1.9	-	-

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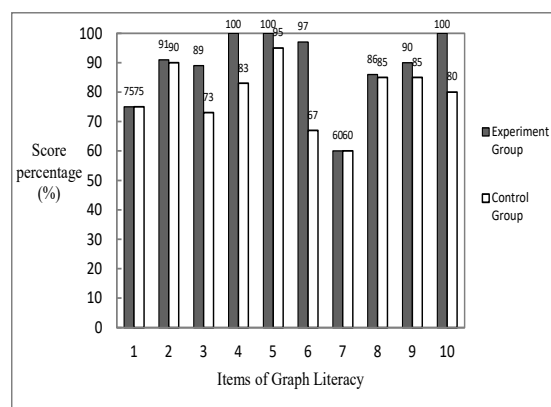
Based on Table 3, it could be explained that the initial ability of the graphical literacy for the experiment group was better ( $M = 66.68$ ; Std. Error  $M = 2.52$ ) than the control group ( $M = 58.40$ ; Std. Error  $M = 4.48$ ). After the learning of free fall movement using computer conducted, there was a significant improvement of the graphical literacy of the experiment group ( $M = 90.29$ ; Std. Error  $M = 1.60$ ) and also for the control group

( $M = 84.05$ ; Std. Error  $M = 1.92$ ). It showed that the learning strategy in both groups could foster the students' graphical literacy. However, if we compare between the strategies, we could see that the computer-based learning strategy could delve the graphical literacy ability more than the traditional strategy. It could be seen from the calculation of normalized gain; the experiment group was better ( $N\text{-gain} = 0.71$ ) than the control group ( $N\text{-gain} = 0.62$ ). The learning which combines the problem based learning, lab inquiry, and assisted by computer have been able to help students to understand the concept of free fall movement well. This finding is at an agreement with research by Ismail et al. (2016) that by exploring multimedia can help students in science learning by giving access to information, measuring, and analysis.

From the analysis results, the difference in impact between the implementation of computer-based learning strategy of free fall movement and traditional learning from the statistical analysis of independent sample t test is shown in Table 4. The gain,  $t(56) = 2.521$  and  $p = 0.021$ . Since  $p < 0.05$  then we could conclude that the computer-based learning strategy of free fall movement in experiment group could delve the graphical literacy better ( $M = 90.28$ ; Std. Error  $M = 1.60$ ) than the traditional learning conducted in control group ( $M = 84.05$ ; Std. Error  $M = 1.92$ ). Error  $M = 1.92$ ). The elaboration of the learning strategy of free fall movement which adopts PBL, lab inquiry, and the computer could improve the students' graphical literacy in finding and formulating the problems. This method is more appropriate for the beginner because they have no provision about the lecture material. This finding also strengthened by the previous research that the example based learning (EBL) could improve the learning performance better than the problem based learning (PBL), because the students were

given example of problems before they have to delve and to find the problems within the learning (Bambang, et al. 2015b). This founding is line with the reserach report that the use of multimedia has shown a positif impact in improving students' scientific literacy where graph literacy is included (Ardianto & Rubini, 2016).

The data of students' graphical literacy collected from experiment activities, students worksheet, and students' presentation is as shown in Figure 7. It can be seen from the figure that the graphical literacy capability of the experiment group is better than the control group. The information that could be got from the implementation of computer-based learning strategy of free fall movement is that the most fostered capability is the ability to identify the research variable. The advantages of the computer-based learning strategy of free fall movement are: students get a chance to think and to solve the problems based on the fact observed and the concept they have.



**Figure 7.** Percentage of the students' graphical literacy which consist of: (1) the students' ability to formulate research questions based on the fact directly observed from the free fall movement device, (2) identifying research variable, (3) operating the device, (4) reading the measurement re-

**Table 4.** Independent sample test for gain score graph literacy with computer-based experiment of free fall movement

Levene's Test of Variances					t-test for Equality of Means		
F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	95% Confidence Interval Of the Difference	
						low	Up
Score graph literacy Equal variances assumed							
.99	.34	2.4	56	.02	6.23	.98	12
Equal variances not assumed							
-	2.5	43.8		.02	6.24	1.18	11

sult, (5) making graph variation, (6) formulating the mathematics equation, (7) interpreting the graph, (8) predicting the graph, (9) concluding the result of experiment, and (10) designing the innovative device of free fall movement.

There were some misconceptions of the students, for instance, that the mass and shape of the object affect the time of falling. Through the exploration of the problem and problem solving through computer-based experiment, students could work better. It is because the sensor connecting the device and the computer is very sensitive so that the movement could be detected well. It would be different when the students measure the time by using a stopwatch. It will make a significant difference in time. The software helps students to ease the measurement and to present the graph. The number of data would not make the students difficult to analyze. This finding also strengthened by another research that the inquiry learning methods influence the academic ability more than the traditional learning method (Cahyani, et al. 2014; Abdi, 2014).

The strategy which combines PBL, lab inquiry and computer assistance helps students to determine the dependent variable, independent variable, and the control variable. The problem presented in the worksheet helps the students to identify the experiment variable because the problems are presented based on the experiment facts and the initial concept brought by the students. The other improved abilities are operating device, reading the measurement result, making graph, formulating mathematics equation, predicting graph, concluding experiment result, and designing an innovative device. The device of free fall movement is equipped with sensor and software which could foster nine among ten abilities of graphical literacy. The ability to predict has not been optimized yet. It is because the students have no experience in reading graph well. In order to help the students to read and to predict the graph, the students were trained to present their experimental results in the presentation session. This method is more effective to improve the ability of graph interpretation in the kinematics of the students of Physics education, the teacher candidates (Bambang, et al. 2015a; Struck & Yerrick, 2010; Jackson, et al., 1993; Zuker, et al., 2015 ). In control, class students have used a timing device manually free fall movement using a stopwatch. This leads to students having difficulties in obtaining data accuracy and number of experiments. This situation results highly influential on students' ability to create charts, create mathematical equations and interpret graphs. This is in

contrast with the free fall motion-based lab computer lab equipped with sensors and software in order to obtain better data with higher numbers of variations. A motion experiment with free fall sensor-based RAISE program has inspired this study to overcome the constraints of the measurement accuracy interval of free fall motion (Yakubov et al. 2005). Developing research (Pendril, et al. 2014) on the use Ipad to observe the trajectory of motion can be easily observed through computer graphics presented in this study.

## CONCLUSION

The computer-based learning strategy of free fall movement consisted of several steps: The first step was students solve the problems in a worksheet by delving problems, formulating problems, determining the variables, and formulating a hypothesis. The second step was doing the free fall movement experiment which consists of saving and taking the note from the observation table, presenting data, and writing the mathematics equation, interpreting, predicting, and concluding the graph. The third step was discussing the result of an experiment with the other groups and the design of the innovative device of free fall movement.

The computer-based learning strategy of free fall movement could improve the graphical literacy better than the traditional learning. The graphical literacy abilities which could be improved were identifying variables, operating device, reading the measurement result, making graph, formulating mathematics equation, predicting graph, concluding experiment result, and designing an innovative device, while the graphical literacy ability which could not be optimized was the ability to predict the graph because the students have no experience to read graph.

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## EFFORTS IN IMPROVING TEACHERS' COMPETENCIES THROUGH COLLABORATION BETWEEN TEACHER FORUM ON SUBJECT MATTER (MGMP) AND PRE-SERVICE TEACHER TRAINING INSTITUTION (LPTK)

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### ABSTRACT

The goal of this study is to improve high school chemistry teacher's competency in terms of classroom instruction. This goal is achieved through the workshop and continuous assistance activities that enable teachers to improve their knowledge and skills in developing learning scenarios that reflect scientific methods (brain-based learning) in the classroom instruction. The effect of teachers' competence improvement was measured by a survey of student's perception on the classroom teaching-learning process, using Likert-scale questionnaire. The first poll was conducted before the program was started, and the second one was after the program completion. The first observation shows that only 18% of students perceive that the chemistry learning process in the classroom are "good," while the rest (82%) say that it is "fair". However, the second poll shows that there are 45% of students who perceive that the learning process is "good"; interestingly, there are 35%, and 20% of respondents say "excellent" and "fair," respectively. Furthermore, data analyses using chi-square test conclude that the continuous teacher assistance activity significantly improves teachers' competencies. This article describes detailed of collaboration program and the results of improvement of chemistry teachers' competence in north Lombok regency.

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**Keywords:** teachers' competences; students' satisfaction; continuous collaboration; pre-service teacher training institution; teacher forum on subject matter

### INTRODUCTION

Indonesian Law No. 14 the year 2005 on Teachers and Lecturers states that teachers are professional educators and must have competencies that include pedagogical competence, professional competence, personal competence, and social competence. Teacher's competence is related to performing duties as a professional educator. It means that a competent teacher is a teacher who has characteristics such as mastering the scientific

substance of his/her study field and able to carry out attracting learning activities for the students to trigger their learning spirit and motivation. Therefore, there is a close relationship between teacher's competence and student's learning satisfaction.

Until nowadays, student's learning satisfaction is still being discussed as an important issue among various learning problems at school. For example, based on the observations of class activity, especially chemistry, in numerous schools shows that there are many students who are not interested / bored / dissatisfied with the learning

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activities which one of the indications is that they are delighted when the chemistry lesson at a certain time is canceled for reasons such as teacher has a meeting, attends a certain ceremony outside school and so on.

According to Kotler, as quoted by Isnaini *et al.* (2016), there are two indicators of satisfaction: (a) Expectations (related to students' perception regarding what they want to achieve), and (b) Performance (related to students' perception of what they have achieved). In the context of the partnership activities, the indicator of students' satisfaction is the performance of teachers as the students have achieved (get involved) the learning activities well so that they have built a perception of the activities.

Numerous empirical studies related to the relationship between teachers' competence and students' satisfaction have been conducted. Panjaitan (2013) reported that 53.30% of students' satisfaction is influenced by the teachers' competence. Furthermore, Puspayani (2012) found that the contribution of professional competence of teachers to students' satisfaction is 39.40%. Other studies related to the same issues have also been reported (Long *et al.*, 2014; Fernandez, 2013; Suarman, 2015). At high education level, it has been reported that lecturers' competence has positive and significant effects on students' satisfaction (Sahin, 2014; Seng, 2013; Winahyuningsih & Edris, 2012; Rahmawati 2013; Lee, 2008; Wu *et al.*, 2010). Of course, there are other factors that influence students' satisfaction in learning that go hand in hand with teachers' competence factors (Widoyoko and Rinawati, 2012; Asto, 2012; Machali, 2011; Wahjanto, 2007; Sutardi and Sugiharsono, 2016; Al-Ajami and Socharto, 2014; Pan, 2014).

It is further known that various strategies have been used to improve teachers' competence. For example, Winarsih & Mulyani (2012) reported that pedagogical competence, professional competence, social competence, and personal competence could be improved through lesson study. Similarly, workshops and mentoring in the PPG program (Professional Teacher Education Program) are able to improve the pedagogical competence of prospective teachers (Anwar, *et al.*, 2012). In addition, the model of lesson study is also used to improve the performance and level of future teacher students' satisfaction (Sumarti, *et al.*, 2015).

From the above description, it can be summarized that to improve students' learning satisfaction, a teacher must have good competencies. Ministry of national education's regulation

16/2007 as quoted by Mulyasa (2012) states that one of the pedagogical sub-competencies is to determine learning strategies based on the characteristics of students, the competence to be achieved, and teaching materials. The last mentioned is much related to professional sub-competence. Therefore, it can be concluded that it is necessary to improve aspects of pedagogical competence and professional competence in order to improve students' learning satisfaction. This is realized in the activities of improving teachers' competence through a partnership between Chemistry Education Study Program of Faculty of Teacher Training and Education of University of Mataram (LPTK) and Teacher Forum on Subject Matter (MGMP) of Chemistry of North Lombok Regency.

## METHODS

This study aims to illustrate the results of collaborative activities between LPTK and MGMP of Chemistry and its impact on teachers' competence improvement, especially related to professional competence and pedagogical competence. The improvement of teachers' competence is measured by students' polls regarding the learning activities of chemistry (learning satisfaction) in the classroom.

The research is conducted in all public SMA / SMK (9 schools) in North Lombok Regency. The activity begins with students' polling through questionnaires, followed by teachers' assistance in developing lesson plan (learning scenarios and supporting instruments) followed by practices, and ending with a second students' polling. The time span between first and second polling is five months. The teacher counseling program is conducted either face-to-face or online, in the form of syllabus analysis of chemistry subject matter; in particular looking at Basic Competencies (KD) relevant to Core Competencies 3 and 4, which are further developed into learning scenarios and supporting media (practical / demonstration instructions, student discussion sheets, project implementation manuals, etc.). The lesson plan describes student learning activities employing inquiry and discovery models that incorporate a scientific approach. At the end of the advisory phase, learning activities in each class were conducted using the lesson plan the teacher had arranged.

The respondents are 524 students from 17 classes (first poll) and 647 students from 20 classes (second poll). Meanwhile, the numbers of chemistry teachers involved in this research are

14 people from 9 public SMA / SMK in north Lombok regency. The results of the polls are then tabulated in the form of contingency tables that include the frequency of occurrence (observed frequency) and estimated expected frequency. The difference between the frequency of occurrence and the estimated expected frequency is then analyzed by chi-square test to see the effect of the partnership program on teachers' competence.

## RESULTS AND DISCUSSION

Improving teachers' competence, which is the objective of this program, was dug out through students' polls about their learning activities in chemistry class. The meaning of "improving competence" is measured by analyzing the difference of the first poll results (before the implementation of partnership program), and the result of the second poll (after the implementation of the program).

Questionnaires used to collect poll data consist of 19 questions with four answer choices. The options are (a) agree, (b) tend to agree, (c) tend to disagree, and (d) disagree. The statement points in the questionnaire are positive statements interspersed with negative statements. Every seven positive statements are followed by a negative one. It is planned to avoid the boredom of respondents in filling in the questionnaire and keep their concentration in reading and understanding the statement points.

Each respondent's answer is given a score and then summed to obtain the total score of each questionnaire. The 19 statement points will be generated a minimum score of 19, and the maximum score 76. The range between minimum score and the maximum score is then grouped into four categories. They are (a) very good, (b) good, (c) fair, and (d) poor. Furthermore, the total score of each class (obtained from the sum of each respondent scores of each class) is calculated to find the average score and categorized. This category is considered as the result of students' polling in each class (the frequency of occurrence or observed frequency). The results of the students' poll are shown in Table 1.

As shown in Table 1 above, there are only 3 out of 17 classes in the first poll (or 18%) surveyed stated that the chemistry learning activity was "good." It implies that 18% of students stated that chemistry teachers "succeed" in teaching them as indicated by their satisfaction in learning chemistry at school. However, it should be noted that students in 14 other classes (or 82%) stated

"fair" or that they felt "less satisfied" with the chemistry learning activity they had.

**Table 1.** The frequency of occurrence (observed frequency) and estimated expected of students' poll about chemistry learning activities at school

Category	Before the Program	After the Program
Very Good	0 (3,22)	7 (3,78)
Good	3 (5,51)	9 (6,49)
Fair	14 (8,27)	4 (9,73)
Poor	0 (0)	0 (0)

\*\*The numbers in parentheses indicate the estimated expected frequency

The result of the preliminary survey indicates that the level of students' learning satisfaction is still low. Therefore, it is necessary to make efforts to improve the performance of chemistry teachers in north Lombok regency. In this case, the teachers need training in pedagogical competence as well as professional competence (understanding the basic concepts of chemistry). Strategies to improve teacher competence should be planned with few "disruption" to the teaching implementation and learning activities in schools. The implementation of learning activities in the classroom is the first priority task of teachers to do.

By considering "the disturbance," the research team did a mentoring to teachers continuously for approximately five months (one semester). Teacher's assistance programs are intended to improve teachers' knowledge and skills in planning learning scenarios and putting them into practice in the classroom. As the mentoring activities need to involve teachers from nine schools, the research team teamed up with teachers' forum (MGMP) in north Lombok regency as partners. Assistance is conducted by face-to-face and non-face-to-face or online (facilitation via electronic mail).

The mentoring begins with a discussion involving all the teachers at the MGMP meeting. From the discussion, the team acquired a picture of the difficulties or obstacles of teachers in implementing teaching plan in schools that related to the lack of learning facilities and infrastructure, the teachers' administration duties, etc. In addition, an agreement was achieved to develop learning scenarios derived from basic competence (KD) in the syllabus of Chemistry Lesson of MIPA (Mathematic and Natural Science) specialization. The compiled scenarios are selected in

accordance with the basic competence to be delivered in each class, either basic competence for class X, class XI, or class XII. In the discussion activities, the development principles of learning scenarios that utilize the scientific method are also discussed. These principles are to be put into operation in the students' class activities plan.

The final session of the meeting is used to practice the design of teaching materials, such as practical instructions, students' discussion sheets, and instruction of learning manuals outside the class and so on. Teaching materials finalizing activity is conducted after the MGMP meeting which includes e-mail and face-to-face meetings at schools (small-scale meetings involving 2-3 schools only; these meetings were held in three areas). Lastly, these final teaching materials are implemented in each classroom that involve teachers' colleagues in the school as observers who record and pay attention to students' learning activities (lesson study model). Classroom observation results were used for learning reflection in each school.

During teacher assistance activity it is found that, generally speaking, the teachers: (a) are not yet accustomed to preparing the lesson plan independently, (b) are less able to analyze the contents of basic competence (KD), and (c) carry out the learning activities based on the materials in certain chapter of a chemistry textbook. The last mentioned results in that teachers experience the materials to be taught are very inflexible. It seems that they have a perception that all material descriptions of a chapter should be taught in the classroom. Of course, this kind of learning is content-oriented and emphasizes more on explanations / lectures, classical questions and answers, and problem exercises.

Content-oriented learning results in the higher burden of teachers who feel rigid and students are less interested in chemistry lessons ending in their dissatisfaction with the learning activities in the class. The results of the first students' poll and of the discussions at the MGMP meeting provides evidence supporting this condition which reports that 82% of the students were unsatisfied with chemistry lessons at school and the teachers say that the subject is very inflexible.

Teacher assistance activity in developing learning scenarios has successfully changed the conditions of the learning activities of chemistry to betterment. It can be seen in the results of a second students' poll which report 7 out of 20 classes (35%) state the learning activity in chemistry class is excellent, and 9 classes (45%) state good, whereas only 5 classes (20%) state fair (see table

1). Thus, teacher assistance activity has successfully: (a) reduced the number of students' dissatisfaction to chemistry learning from 14 classes to 4 classes, (b) increased students' satisfaction from 0 to 7 classes which express very satisfied, and (c) increased the number of satisfied students from 4 classes to 9 classes.

Furthermore, the influence of this partnership program on teachers' competence is quantitatively calculated from the contingency table analysis (Table 1) by chi-square test comparing the difference between the frequency of occurrence ( $f_{ij}$ ) and estimated expected frequency by using formula  $V_{hit}$ . It is obtained a  $V_{hit}$  of 14,00 with  $\chi^2_{tabel}$  and  $d_f = (4-1)(2-1) = 3$  is 11,345 with significant level  $\alpha = 0,01$ . Thus, it has been statistically proven that there is a relationship between the partnership program and teachers' competence meaning that teacher assistance program to develop lesson plan is able to significantly improve teachers' competence (pedagogical and professional). The enhance teacher's competence may also be seen from the products of learning scenarios prepared by the teacher who will have practice in class. In such scenarios, the student's activity is obviously described that encloses steps of scientific methods such as observing, measuring and collecting data, analyzing data and making inferences. To design such scenarios, it is necessary to adequately master the basic concepts of science (professional competence) and to find creative and interesting strategies that match to the local condition (pedagogical competence). Finally, the implications of improving teacher's competence are increasing students' satisfaction in learning chemistry. It means that students become more interested and more passionate in keeping to the learning activities in chemistry class.

## CONCLUSION

The partnership program between MGMP (Teacher Forum) and LPTK (Pre-service Teacher Training Institution) is able to improve the professional competence and pedagogical competence of chemistry teachers in north Lombok regency. This conclusion is derived from the teachers' ability in developing learning scenarios oriented to students' learning activities based on principles of scientific methods. Thus, the learning activities become more attractive for the students as they engage in class activities. The impact is students' satisfaction in keeping to the learning activities increased significantly at the end of the program than before the program implemented. The statistical test of the students' poll results confidently



supports this conclusion. Thus, the outcomes of this partnership program can be beneficial to local governments (especially education and cultural office) as a basis for consideration in formulating policies to improve teachers' competence in cities / districts throughout the province of West Nusa Tenggara.

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## ANALYSIS OF STUDENTS' DIFFICULTIES ABOUT ROTATIONAL DYNAMICS BASED ON RESOURCE THEORY

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### ABSTRACT

Students' difficulties commonly are analyzed based on misconception theory. This paper aimed to analyze students' difficulties on the rotational dynamic based on resource theory. The subject of research consisted of 108 first-year undergraduate students of Physics Education, State University of Malang. Firstly, the students were asked to solve 15 multiple-choice questions and gave open explanation. We then implemented a constant comparative method to identify and categorize some resources that students employed in solving several problems that most the students failed to respond correctly. The results indicated that the students had difficulties in solving problems related to the torque and the equilibrium of rigid body. The students' difficulties were not merely caused by the lack of correct knowledge. Instead, they have the correct knowledge or resources but they activated them on inappropriate context. The students will be successfully used the resources to solve problems if they activated them in the right context.

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**Keywords:** students' difficulties; rotational dynamics; resource theory

### INTRODUCTION

Understanding fundamental concepts and the relationship between concepts, and able to use the concepts to solve problems are ones of objectives to be achieved by students in learning physics. However, many students have difficulty in understanding and applying physics concepts to solve the problems (Demirci 2008; Gracia et al., 2008; 2010; Nguyen & Rebello, 2011; Maries & Singh, 2016; Bollen et al., 2016). Students difficulties to solve physics problems can be explained using two different viewpoints; they are misconceptions and resource theory (Docktor & Mestre, 2014). According to the misconceptions theory, students failure in solving a problem is caused by the students' knowledge that is irrele-

vant to the scientific concept called misconception (Clement, 1982; Khazanov, 2010; Leinonen, 2013; Widarti et al., 2016). Misconceptions are difficult to change (Berek et al., 2016; Wijaya et al., 2016; Docktor & Mestre, 2014), consistently used to solve several problems presented in various contexts (McDermott, 2001; Sabo et al., 2016), and need a great effort to replace them with the appropriate knowledge that in line with the scientific concept (Sencar & Erylmaz, 2004).

On the other hand, resource theory suggests that students who fail in solving a problem do not necessarily hold incorrect knowledge or resources. However, in fact, they might have right knowledge, but they fail to activate the knowledge in the right context (Hammer, 2000). It is because their knowledge is still in pieces, and tend to be activated in a certain context (DiSessa et al., 1998). For example, two stones of the same shape but different mass dropped from the same height

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at the same time, which one will first reach the ground? Students might answer that the rock with greater mass will reach the ground first. In this context, students activate the resource that heavy objects fall faster than light objects. Students answer is incorrect, but the resource is correct. The resource is right if it is activated in the context of a rock and a piece of paper are dropped together from the same altitude and the air friction can not be neglected.

Based on the illustration, the resources that students activated are not merely wrong or irrelevant to the scientific concept. But it could be right if it is activated in the right context. In other words, the activated resource is highly dependent on the context (Hammer, 2000; Docktor & Mestre, 2014).

Unlike the misconception theory that only looks at the pattern of understanding which is not in accordance with the scientific concept (Sabo et al, 2016), the resource theory considers more on all resources that are activated to develop or build the concept that is in accordance with the scientific concept (Hammer, 2000; Jeličić et al., 2017). Therefore, the view of resource theory give more in-depth explanation related to knowledge that is owned and activated by the students when troubleshooting.

Rotational dynamics is an important topic in physics. This material is classified as complex because it assesses the rotational motion and the cause of the motion and it is elusive for students (Lopez, 2003; Phommarach, 2012). Several studies have revealed students difficulty to understand rotational dynamics (Ortiz et al, 2005; Rimoldini and Singh, 2005; Unsal, 2011; Mashood and Sigh, 2012; Close et al, 2013; Ambrosis et al, 2015; Khasanah et al, 2016; Rahmawati et al, 2016). Students difficulties that were revealed by Rimoldini & Singh (2005) and Rahmawati et al. (2016), are including 1) distinguishing the amount of speed at some points on the wheel that rolls without slip, 2) distinguishing between torque and force, 3) interpreting the relation of net torque and the angular acceleration. Ortiz et al. (2005) also found out that students experienced difficulties regarding 1) distinguishing between torque and force, and, 2) interpreting the definition of torque  $\vec{\tau} \equiv \vec{r} \times \vec{F}$  primarily determining the practical vector point of force towards a particular axis ( $\vec{r}$ ). Mashood & Singh (2012) found out that students had difficulties in determining the speed and direction of the angular acceleration of the pendulum swinging. Students also believed that the direction of the vector  $\vec{\omega}$  and  $\vec{\alpha}$  are in the direction of motion of a body.

While many researchers had already revealed student's difficulties in understanding rotational dynamics, but so far not many of them that revealed the cause of the difficulties. This article is focused on identifying the student's difficulties in understanding the rotational dynamics material observed by the resource theory.

## METHODS

This study used the descriptive qualitative method to reveal the difficulties and resources which were activated when the students solved problems related to the rotational dynamics. The subjects of this study consisted of 108 first-year undergraduate Physics Education students of Malang State University who had learned rotational dynamic concepts in an academic year of 2016/2017.

The data were obtained from the student's responses when answering 15 multiple-choice questions and explaining their arguments. The sub-material that were presented in are rotational kinematics (Question 1-5), torque (Question 6-9), rolling motion (Questions 13 and 14), the angular momentum (Question 10-12), and equilibrium rigid body (15). However, this article only analyzed sub-materials that were elusive for students.

From the 15 questions that were tested, it was obtained two problems with the lowest percentage of correct answers which is the question number 9 (17.4% of subjects) and number 15 (17.4%). The low percentage of correct answers show that the problems were difficult to solve by students so that they need the more in-depth discussion of the student's difficulties regarding resource theory. Furthermore, the analysis of students' wrong answers on numbers 9 and 15 is conducted. In the first phase, the students' wrong answers were grouped according to the option they chose. Secondly, students' reasons were inventoried from each group of choices; then they were grouped into several categories of resources which were activated by students using the constant comparative method (Luehmann, 2009; Middendorf & McNary, 2011; Anderson & Wall, 2015; Demirdogen, 2016). Interviews were also conducted to deepen further the students' reasons in answering the questions.

## RESULTS AND DISCUSSION

The question number 9 access students' ability to determine the direction of torque produced by the gravity of a wheel against a particular axis. The question used in the tests can be

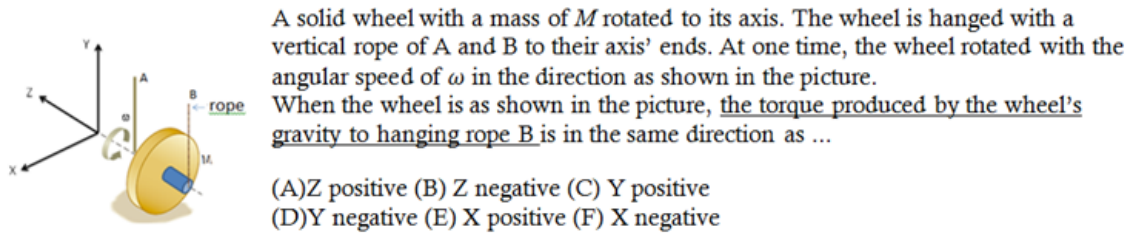


Figure 1. Question Number 9 on The Test

seen in Figure 1.

To successfully solve the problem, the students should be able to activate multiple resources properly as follows: 1) the definition of torque is  $\vec{\tau} \equiv \vec{r} \times \vec{F}$  and apply it to the torque by gravity  $\vec{\tau} = \vec{r} \times \vec{w}$  with  $\vec{r}$  as position vectors of the gravity working point (positive direction of the Z-axis) and  $\vec{w}$  as gravity vector (negative direction of the Y-axis), 2) the center of gravity concept and apply it to determine the position of the center of gravity wheel (i.e. in the middle of the axle), 3) The rotary axis to which gravity provided the torque (same as the direction of the rope B in accordance to the question), 4) determines the direction of the cross product result  $\vec{\tau} = \vec{r} \times \vec{w}$  (because  $\vec{r}$  towards Z positive and  $\vec{w}$  to Y negative thus  $\vec{\tau}$  directed to X positive axis) as shown in Figure 2 or may follow the right-hand rule.

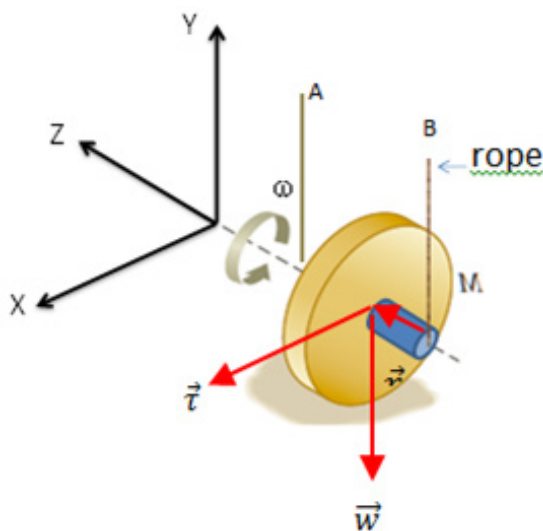


Figure 2. The Torque's Direction Produced by Wheel's Weight

The students who answered the question correctly had successfully activated and assembled some of these resources. The other students chose the wrong answers by activating some resources as distributed in Table 1. The students thinking, and resources that were activated in selecting the wrong answers are described as follows.

A total of 29.6% of the students chose B that the direction of the torque produced by the wheel's gravity of a hanging rope B is in the direction of the Z negative axis. Those who chose this answer have arguments that were grouped into two categories as shown in Table 1. The students who chose answer B category 1 thought that the torque is the cause of the rotating object. The direction of torque determine the rotation direction, and the magnitude of torque determine the magnitude of the angular velocity. So, the magnitude and direction of the torque are proportional to the magnitude and direction of the angular velocity. By using the right-hand rule, when the wheel rotate counter clockwise then  $\vec{\omega}$  to the Z negative so that the direction of  $\vec{\tau}$  is also to the Z negative Z.

Based on the thinking above, it can be identified the resources that had been activated by students in choosing answer B category 1. First, students had been able to determine the direction of  $\vec{\omega}$  with the right-hand rule so that it is obtained  $\vec{\omega}$  is in the direction of Z negative axis. The activated resources are the right knowledge. However, they are inappropriate if activated in the context of the questions asked. Second, students activated that  $\vec{\tau}$  is the cause of a rotating object. The direction of  $\vec{\tau}$  determine the rotation direction, and the magnitude of  $\vec{\tau}$  determine the magnitude of  $\vec{\omega}$ . So, the magnitude and direction of  $\tau$  are proportional to the magnitude and direction of  $\vec{\omega}$ . This resource is the wrong knowledge. The resource is built from the first experience in studying the torque which is when pushing or pulling the door until the door opened and closed. The direction of the door rotation depend on the direction of the force. The door rotation speed depend on the strength of the given push or pull and the location of the working point of the push or pull force. Having introduced the concept of torque; concerning the events of opening and closing the door, the students built the knowledge of phenomenological "torque is the cause of rotating object; the magnitude and direction of the torque determine the magnitude and direction of the object's rotation speed or  $\vec{\omega} \sim \vec{\tau}$ ." This



**Table 1.** The Wrong Answers Distribution and Resources that Activated to Solve Question Number 9

Answer Choices	The Number of Students	Resources that were Activated by the Students
A	16 (14.8%)	Unclear
B	32 (29.6%)	<p>1 <math>\vec{\tau}</math> as the cause of the rotating object. The direction of <math>\vec{\tau}</math> determine the direction of rotation and the magnitude of <math>\vec{\tau}</math> determine the magnitude of <math>\vec{\omega}</math>. So, the magnitude and direction of <math>\vec{\tau}</math> are proportional to the magnitude and direction of <math>\vec{\omega}</math>. The direction of <math>\vec{\omega}</math> determined by the right-hand rule. Since the wheels are rotating counter clockwise, then <math>\vec{\omega}</math> in the Z negative direction. Because the direction of <math>\vec{\tau}</math> is the same with <math>\vec{\omega}</math>, then <math>\vec{\tau}</math> in Z negative direction.</p> <p>2 <math>\vec{\tau}</math> is the cause of the rotation speed change according to the relation of <math>\sum \vec{\tau} = I\vec{\alpha}</math>. The direction of <math>\vec{\alpha}</math> is the same with <math>\vec{\omega}</math> because it is accelerated. The direction of <math>\vec{\omega}</math> determined by the right-hand rule. Since the wheels are rotating counter clockwise, then <math>\vec{\omega}</math> in the Z negative direction so that the direction <math>\vec{\tau}</math> in the Z negative.</p>
C	20 (18.5%)	There is always a torque in a rotating object. Force generates torque on a rotating object. The torque is associated with the force, the direction of torque is the same with the force on the wheel which is the tension straps.
D	12 (11.1%)	There is always a torque in a rotating object. Force generates the torque on a rotating object. The torque is associated with the force, the direction of torque is the same with the force on the wheel which is the wheel's gravity $\vec{W}$
F	7(6.5%)	Unclear

knowledge is included in the category of p-prime because it was built without sufficient abstraction (DiSessa, 1993; Hammer, 1996). In constructing the knowledge, the students did not pay attention to the beginning of the movement of the door before affected to torque, that was at rest. If the students were watching it, then the rotation speed was not of concern, but the rotation speed changes.

The students who chose answer B category 2 argued that the torque is the cause of change in the rotation speed according to the relation of  $\sum \vec{\tau} = I\vec{\alpha}$ . The direction of  $\vec{\alpha}$  is the same as the direction of  $\vec{\omega}$  because they perceived that the wheel was idle at first to move at the speed of  $\omega$  or accelerated. The direction of  $\vec{\omega}$  determined by the right-hand rule. Since the wheel is rotating counterclockwise, then  $\vec{\omega}$  to the Z negative direction so that the direction of  $\vec{\tau}$  is also in the Z negative.

The students who chose answer B category 2 activated resources that are more sophisticated than students who chose answer B category 1. First, because they paid attention to the initial state of the door which was idle, so that the activated resource "the torque is the cause of rotati-

on speed changes according to the relation of  $\sum \vec{\tau} = I\vec{\alpha}$ ." Second, they activated that the direction of  $\alpha$  is the same with  $\vec{\omega}$  because they perceived that the wheel was idle at first then it moved at the speed of  $\vec{\omega}$  or accelerated. Third, the direction of  $\vec{\omega}$  is determined by the right-hand rule. The three resources which were activated are all the right knowledge and will be successfully used to solve the problem in the context of a spinning wheel to the axis through the axle. However, because the question asked about the torque generated by the gravity of the hanging rope B, then the concept of torque which is activated should be the torque generated by each force that worked on the wheel, not the resultant torque according to the relation of  $\sum \vec{\tau} = I\vec{\alpha}$ .

Based on the written arguments on the answer sheet and from interview, the students who chose answer B category 2 had two correct resources torque-related, they are  $\vec{\tau} \equiv \vec{r} \times \vec{F}$  and  $\sum \vec{\tau} = I\vec{\alpha}$ . However, resource  $\sum \vec{\tau} = I\vec{\alpha}$  is more dominant and easily activated to solve question number 9, because, in the question, it is presented that  $\vec{\omega}$  is considered to be more related to  $\vec{\alpha}$ . It indicated that resources which activated by students relied

heavily on the dominant context in the question (Hammer, 2000; Docktor & Mestre, 2014).

Students who chose answer C (18.5%) and D (11.1%) were both activated the resource that there is always a torque on rotating object. The torque generated by the force which works on a rotating object. Therefore, students in this group associated torque with force and found out that the direction of the torque is the same as the working force on the wheel. The activated resource was the correct knowledge. Nevertheless, this activated resource is not enough to solve the question number 9.

The students who chose answer C only recognized the tension rope that worked on the wheel as shown in the figure in the question. Because the rope tension working on the wheel is in the direction of the Y positive axis, and the direction of the torque is the same as the force, then the torque's direction is also to the Y positive. This reasoning showed that the students had difficulties in analyzing other objects which interacted with the wheel, so they did not succeed in identifying the forces that worked on the system (Savinainen et al., 2013; Aviani et al., 2015). Meanwhile the students who chose answer D had been able to identify the direction of gravity, which produced the torque to the axis of hanging rope B. But because the resource of torque is the cause of objects' rotation and generated by the force that was working on a rotating object was activated, without being followed by the activation of a resource that defines the torque as  $\vec{\tau} \equiv \vec{r} \times \vec{F}$ , then it is obtained a false claim that the torque is in the same direction of the force.

Based on the students thinking above and confirmed in interview, it was found that the students have had the correct resources to be used to solve question number 9. Their resources are 1) there is always a torque in rotating objects, 2) the torque is generated by the forces working on rotating objects, 3)  $\vec{\tau} \equiv \vec{r} \times \vec{F}$ . However, the concept of the force that they have is more dominant than the concept of torque, so the concept of force is activated more quickly to resolve the problem in question number 9. It showed that the students'

resources had not been coupled coherently so that the less dominant resource will be delayed to activate than the more dominant resource (Hammer, 2000).

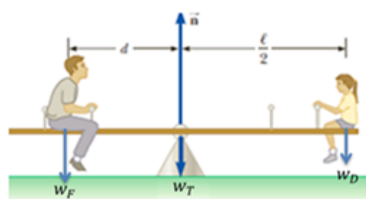
The question number 15 access students' ability in determining the torque equation to a particular axis when the system is in a static equilibrium state. The tested question can be seen in Figure 3.

To solve the question correctly, students should be able to activate the following resources: 1) the requirements of static equilibrium system are  $\sum \vec{\tau} = 0$  and  $\sum \vec{F} = 0$ , 2) the definition of torque is  $\vec{\tau} \equiv \vec{r} \times \vec{F}$ , 3) the rotary axis can pass through or outside of the body. If all of these resources are correctly activated, then the equation (A) met  $\sum \vec{\tau} = 0$  with the vertical axis passing through seesaw's fulcrum. The equation (B) also met  $\sum \vec{\tau} = 0$  with the vertical axis passing through the Father. Likewise, the equation (C) met  $\sum \vec{\tau} = 0$  with the vertical axis passing through the Daughter. While equation (D) is not correct because the equilibrium condition  $\sum \vec{F}_y = 0$  obtained  $\vec{n} = \vec{w}_T + \vec{w}_F + \vec{w}_D$ . Thus the most appropriate answer is (F).

Only 17.4% of the students chose the correct answer. Others chose the answer with some resources that were activated as shown in Table 2. The students activated thought and resource that chose the wrong answer is described as follows.

A total of 43.5% students chose answer A thought that on the balanced seesaw, the spin axis always lied at the fulcrum. The balanced seesaw meant fulfilling the equation  $\sum \vec{\tau} = 0$ . Each torque generated by force is defined as  $\vec{\tau} \equiv \vec{r} \times \vec{F}$  so that it is obtained that equation  $w_F \times d = w_D \times \frac{\ell}{2}$  is a correct equation in describing the state of the seesaw. In the context of this question, the students had managed to activate some of the resources, which are: 1) the requirements of a static equilibrium system is  $\sum \vec{\tau} = 0$ , 2) the definition of the torque is  $\vec{\tau} \equiv \vec{r} \times \vec{F}$ , 3) the spin axis passing through the fulcrum. The resource that has been activated is a correct knowledge and will be appropriately used to solve the question with the spin axis at the fulcrum. The students in this group only activated resource with just one spin axis at the

Look at the force diagram that worked on a seesaw that was played by the Daughter and Father in the picture. If it is in the balanced state, which of the following equation that is appropriate to the picture?



- (A)  $w_F \times d = w_D \times \frac{\ell}{2}$   
 (B)  $n \times d = w_T \times d + w_D \times (d + \frac{\ell}{2})$   
 (C)  $n \times \frac{\ell}{2} = w_T \times \frac{\ell}{2} + w_F \times (d + \frac{\ell}{2})$   
 (D)  $n = w_T$   
 (E) All choices (A) to (D) is correct  
 (F) All choices (A) to (C) is correct

Figure 3. Question Number 15 on the Test

**Table 2.** The Wrong Answers Distribution and Students Resource in Solving Question Number 15

Answer Options	The Number of the Students	Students Activated Resource
A	47 (43.5%)	The spin axis is always located in the fulcrum The requirement for equilibrium is $\sum \vec{\tau} = 0$ $\vec{\tau} \equiv \vec{r} \times \vec{F}$
B	5 (4.6%)	Unclear
C	2 (1.9%)	Unclear
D	(10.2%)	Unclear
E	23 (21.3%)	The requirement for equilibrium are $\sum \vec{\tau} = 0$ and $\sum \vec{F} = 0$ $\vec{\tau} \equiv \vec{r} \times \vec{F}$ $\sum F = 0, n - w_T = 0, n = w_T$ The spin axis can pass through the Father, Daughter, and fulcrum

fulcrum. When confirmed in the interview, they knew that the spin axis could pass through or outside of the body. However, because the question is presented in the form of a seesaw, they were more quickly activated the resource that the axis is at the fulcrum. It suggested that in addition to the activated students' resource which depended on the context (Sabo et al., 2016), the students' ability to solve problems are often seen the dominant matter presented in the question (Docktor & Mestre, 2014).

The students who chose answer E thought that in the balanced system is applied  $\sum \vec{\tau} = 0$  and  $\sum \vec{F} = 0$ . The torque generated by each force defined as  $\vec{\tau} \equiv \vec{r} \times \vec{F}$ . The spin axis can be selected to pass through the Father, the Daughter, and the fulcrum so that referring to the equation  $\sum \vec{\tau} = 0$  and  $\vec{\tau} \equiv \vec{r} \times \vec{F}$ , the equations in options A, B, and C are correct. The requirement of translational equilibrium fulfilled the equation of  $\sum F = 0$  and  $n - w_T = 0$  or  $n = w_T$ .

Based on the students thought, they have activated resources in the right context, which are: 1) In an equilibrium system applied the condition of equilibrium  $\sum \vec{\tau} = 0$  and  $\sum \vec{F} = 0$ , 2)  $\vec{\tau} \equiv \vec{r} \times \vec{F}$ , 3) the spin axis can pass through the Father, the Daughter, and the fulcrum. However, when applying the translational equilibrium condition of  $\sum \vec{F} = 0$ , students simply activated the forces working on the fulcrum. When confirmed in the interview, they argued that since the seesaw is in an equilibrium state and the axis through the fulcrum, the force on the right side (gravity by Daughter) and the left side (gravity by Father) canceled each other out. Therefore, only two forces that were working, they are  $w_n$  and  $w_T$ , so that by referring to the equation of  $\sum \vec{F} = 0$ , then  $n - w_T = 0$  or  $n = w_T$ . This reasoning indicated that the students had all the resources necessary to solve the problems. But the structure of this resource is not coupled

coherently (DiSessa et al., 1998).

## CONCLUSIONS

The results showed that students had difficulty in solving problem related to the torque and rigid body equilibrium. This difficulty is not caused by their misconception, but the knowledge or resource that they activated was not appropriate in the questions' context. For example, a student failed to determine the direction of the torque generated by the gravity of the hanging rope because he activated the resource of equation  $\sum \vec{\tau} = l\vec{\alpha}$ . This equation is not wrong, but it was not activated in the proper context. The students have had resource  $\vec{\tau} \equiv \vec{r} \times \vec{F}$  and  $\sum \vec{\tau} = l\vec{\alpha}$ , but resource  $\sum \vec{\tau} = l\vec{\alpha}$  is more dominant in students cognitive structure and easily activated to solve the questions. Therefore, the student's resource, which is activated dependently on the context that emerged dominant in the questions.

Based on these findings, in teaching the material of rotational dynamics, it is suggested that the teachers presented a phenomenon or problem that multi-context and multi-representation. It will help students activated and assembled its multiple resources coherently to be applied in the right context.

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## PROFILE OF STUDENTS' CREATIVE THINKING SKILLS ON QUANTITATIVE PROJECT-BASED PROTEIN TESTING USING LOCAL MATERIALS

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### ABSTRACT

The purpose of this study is to obtain a profile of students' creative thinking skills on quantitative project-based protein testing using local materials. Implementation of the research is using quasi-experimental method pre-test post-test control group design with 40 students involved in Biochemistry lab. The research instrument is pre-test and post-test using creative thinking skills in the form of description and students' questionnaire. The analysis was performed with SPSS 22.0 program to see the significance normality, U Mann-Whitney test for nonparametric statistics, N-Gain score, and the percentage of student responses to the practicum performed. The research result shows that the pretest rate in the experimental group is 8.25 while in the control group is 6.90. After attending a project-based practicum with local materials, the experimental group obtained the mean of posttest is 37.55 while in control class is 11.18. The students' improvement on creative thinking skills can be seen from the average of N-Gain in the experimental class with 0.32 (medium category) and in the control category with 0.05 (low category). The experimental and control class have different creative thinking skills significantly different fluency, flexibility, novelty, and detail. It can be concluded that quantitative project-based protein testing using local materials can improve students' creative thinking skills. 71% of total students feel that quantitative project-based protein testing using local materials make them more creative in doing a practicum in the laboratory.

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**Keywords:** creative thinking skills; project-based practicum

### INTRODUCTION

Creative thinking skill is one of the important cognitive aspects that must be considered in the process of learning science in the classroom. One of the learning process of science in college is realized in the course lab. So far, the assessed cognitive aspect from the practicum course does not cover the creative thinking skills, whereas many phases of practicum in lab require students' creative thinking skills for example when they have to choose the practicum materials. Fatmawati (2016) states that creative thinking

skills are required in science learning especially in Biotechnology. Some other studies have also found the relationship of creative thinking skills to experimental activities in the lab. Experimental activities can make students do a practicum with hands on as well as minds on activity (Bellin, Bruno, and Farrow, 2010; Coleman, 2010; Witherow and Carson, 2011; Trapani and Clarke, 2012).

The students' activities in the practicum include investigation through experiments encourages the students to give questions, propose hypotheses, make predictions, use tools to collect and analyze data, make conclusions, build arguments, discuss findings, and use broad reasoning strategies involving skills in thinking creatively,

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critically, causally, and logically (Chin and Chia, 2005; Hong and Kang, 2009).

One of the ways to realize a practicum that is able to develop creative thinking skills is by choosing the right learning model. Sari (2015) says that students like practicum that can make them free to design and examine. An appropriate learning model with that purpose is a project-based learning model. Project-based learning model (perceived learning) can trigger students' creative thinking skills. The main purpose this learning is to enable students to practice what they learn by integrating theory and practice. Furthermore, students can develop their creative thinking skills to solve life and environmental challenges later (Yilmaz and Cavas, 2007; Holubova, 2008; Yalcin, Turgut, and Büyükkasap, 2009; Bell, 2010; Eskrootchi and Oskrochi, 2010; Treacy, 2011; Bjorner, Kofoed and Pederson, 2012; Lou et al., 2012; Hsieh, Lou and Shih, 2013; Robinson, 2013; and Husamah, 2015).

In this study, the researchers utilize local materials aiming to initiate the students' creative thinking skills in selecting the materials in the lab. The environmental approach in learning can increase students' awareness of the environment (Ashraf, 2013), build creative thinking skills and student creative attitudes (Nuswowati and Taufiq, 2015). The close relationship between creative thinking skills in laboratory activities and learning models makes the researchers interested in looking for the profile of students' creative thinking skills on quantitative project-based protein testing using local materials.

## METHODS

The method of this research is quasi-experimental research with pretest and posttest control group design (Fraenkel & Wallen, 1993). The subject of the study are 40 students attending the biochemistry lab, and they are divided into 6 groups.

In this study, there are the control group and experimental group. In the control group, a quantitative lipid analysis is performed as written in the guidebook. At the end of the meeting, the students are given a test in the form of explanation to test the students' creative thinking skills in a practicum.

The practicum of quantitative protein analysis is done in an experimental group. The practicum is done based on the project by using local materials around the students' environment as practicum materials. Students are required to determine titles, local materials, tools, procedures

appropriate to local materials. At the end of the meeting, the students are given explanation test used to test students' creative thinking skills in lab practicum.

Quantitative and qualitative data instruments are used altogether in this study. For quantitative data collection is done by testing the students on their creative thinking skills. 7 tasks of written test instruments are in the form of explanation. The test is used to measure the students' creative thinking skills before and after the class. Each question represents an indicator of creative thinking skill including students' fluency, flexibility, novelty, and detail (Torrance, 1972). Qualitative data are obtained through questionnaire aiming to see students' responses to the implementation of quantitative project-based biomolecule experiments with local materials.

The data are processed using SPSS 22.0 program to see whether it is normally distributed or not. The creative thinking skill test is used to measure the N-gain value by Hake formula (Meltzer, 2002) from the average of pretest and posttest. Qualitative data are used as questionnaires in scale and measured by the percentage of each attitude scale.

## RESULTS AND DISCUSSION

In this study, there are the control group and experimental group. In the experimental group which uses quantitative project-based protein testing using local materials, students are required to determine the title, objectives, materials, procedures independently. In the control group, the students in groups performed a quantitative lipid analysis experiment as written in the guidebook. Finally, the posttest is done to see the profile of students' creative thinking skills. A summary of the quantitative practice of protein and lipid analysis can be seen in Table 1.

From the distribution of practicum activities in table 1, the quantitative analysis of student lipids is only done based on the guidebook. Titles, objectives, materials and procedures are included in the guidebook.

Different things can be seen in the quantitative analysis of proteins. The title and the purpose of the practicum are determined by the students themselves. The materials in the practicum are from local materials around students such as pempek, bread, rice, sausage and salted fish. Students want to see if the materials around them are really the protein source and really contain protein. Some ingredients known to contain carbohydrates such as rice and bread are also tested

**Table 1.** Practicum distribution activities of quantitative analysis of lipids and proteins

	Quantitative Analysis of Lipid	Quantitative Analysis of Protein
Learning Model	Practicum with guidebook	Project-based practicum using local materials
Local Materials	Oil	Pempek, bread, rice, sausage, salted fish
Procedure	Peroxide numbers determination	Formal titration, lowry's method

for quantitative analysis of proteins. Students want to see whether by consuming local materials containing carbohydrates can also fulfill the body's need for protein.

In this practicum, students in groups are free to choose quantitative protein procedures namely formal titration and lowry method. Formal titration and lowry method can be used to measure the amount of protein content in a sample. This thing has been done by Fahmid et al. (2016) and Krishnaveni and Dhanalakshmi (2014) for calculating the total protein content in food by using the lowry as one of the methods.

By using the SPSS 22.0 program, it can be seen whether or not the distribution is normal. The normality test results can be seen in Table 2.

**Table 2.** Normality Test

	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Pre-lipid	.206	40	.000	.825	40	.000
Post-lipid	.191	40	.001	.907	40	.003
Pre-protein	.216	40	.000	.897	40	.002
Post-protein	.175	40	.003	.965	40	.241

The normality test results show p-value which calculated by Shapiro-Wilk test is smaller than  $p < 0.05$  which means that the data is not normally distributed. Further data will be analyzed with nonparametric statistics.

### Creative Thinking Skill Test

To see the influence of biomolecule quantitative analysis on students' creative thinking skill, the test is done in control and experiment group. Each question represents an indicator of creative thinking skills such as fluency, clarity, novelty and detail (Torrance, 1972).

The average score of pretest and posttest results can be seen in Table 3 and 4.

The quantitative project-based protein testing using local materials gives effect on the improvement of students' creative thinking skill.

The increase has reached a gain of 0.32 in the medium category. It is different from table 4.

**Table 3.** The average score of pretest and posttest and N-gain in the experimental group

	Pretest	Posttest
Mean	8,25	37,55
N gain	0,32	
Category	Medium	

**Table 4.** The average score of pretest and posttest and N-gain in control group.

	Pretest	Posttest
Mean	6,90	11,18
N-gain	0,05	
Category	Low	

It can be seen in table 4 that the increase of students' creative thinking skill does present before and after the practicum in quantitative analysis of lipid although the N-gain is 0,05 which means low.

After the data is known not normal, it is then tested using comparative hypothesis known as U-Mann-Withney test on pretest and posttest. A comparative hypothesis test is used to determine whether the data differ significantly or not. The value is seen in this test to search the Sig value (2-tailed). Then compared with the level of trust 5% ( $\alpha 0,05$ ). If the sig. (2-tailed)  $< 0,05$ , the data are significantly different, if the sig. (2-tailed)  $> 0,05$  the data are not significantly different. It can be seen in the following Table 5 as the results of U Mann-Withney pretest data:

**Table 5.** The U Mann-Withney pretest data results

Kind of Data	Sig. (2 tailed)	$\alpha$	Decision	Information
Pretest	0,272	0,05	H0 is rejected	Not Significantly different

Table 5 shows Sig. (2-tailed) of pre-test in the control and experimental group is 0,272 with the level of trust 5% ( $\alpha 0,05$ ). The decision is H0 is rejected which means the students in control



and experimental group are not significantly different or having the same basic knowledge

To see the results of *U-Mann-Whitney* test on posttest can be done by looking at Table 6.

**Table 6.** The test result of U *Mann-Whitney* post-test data.

Kind of Data	Sig. (2 tailed)	$\alpha$	Decision	Information
Posttest	0,000	0,05	H0 is accepted	Significantly different

Table 6 shows the *Sig. (2-tailed)* of posttest data is 0,000. The decision is H0 is accepted because  $0,000 < 0,05$ . The data are significantly different, and this means that the students in the control and experimental group have different creative thinking skills.

Project-based practicum with local materials enables students to think creatively in terms of searching materials from their surroundings and also looking for appropriate procedures. This is in accordance with previous researches where project-based models can make students creative (Bjorner, Kofoed, & Pederson, 2012; Husamah, 2015), give clear and better understanding (Treacy, 2011), make the students get involved because the learning activity is centered on students (Bell, 2010) and enable the students to relate the practicum with daily life (Eskrootchi and Oskrochi, 2010; Yilmaz dan Cavas, 2007; and Nuswawati & Taufiq, 2015).

The student's response on the project-based quantitative analysis practicum can be seen on questionnaires. The measured aspects in the questionnaire are positive attitudes and perceptions of the quantitative project-based protein testing using local materials as well as an optimistic attitude to the learning's success. The result shows that 71% of students agreed that the lectures of quantitative project-based protein testing using local materials make them more creative in doing the practicum.

## CONCLUSIONS

It can be concluded from the research that:  
 1) Quantitative project-based protein testing using local materials can improve the students' creative thinking skills with the N-Gain is 0,32; 2) Students agree that quantitative analysis practicum on biomolecules with local materials makes them more creative for example in choosing the materials and practicum procedures.

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## SENIOR HIGH SCHOOL STUDENTS' DIFFICULTIES IN SOLVING IMPULSE AND MOMENTUM PROBLEMS

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### ABSTRACT

Impulse momentum theorem is one of the fundamental principles of physics, especially in mechanics. Therefore, students' understanding of impulse and momentum will contribute to their success in learning physics. This study exposed common students difficulties in solving problems related to impulse and momentum. The subjects consisted of 175 students of a Senior High School in Malang, 70 students of grade XI who recently learned about impulse and momentum and 105 students of grade XII who relearned the topic for national examination preparation. The data were gathered using multiple-choice test with open explanation and confidence rating scale. The study concluded that the students' difficulties were not only caused by their lack understanding of the concepts but also by their deficiency in using vectors.

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**Keywords:** students' difficulties; impulse and momentum; student conceptual understanding

### INTRODUCTION

One of the important goals of learning physics is to facilitate students to grasp fundamental physics concepts and to apply them to solve related physics problems. However, to reach these aims is not as easy as one thinks. It is because students often have mistakenly formed conceptions when they come to physics lessons (Halim et al., 2014) or they have not understood the basic knowledge before they learn new concepts (Turányi & Tóth 2013). Many physics educators label such mistaken or contradicting thoughts as misconception (Lawson, 1995; Hammer, 1996; Chamber & Andre, 1997; Yalcin, 2008; Docktor & Mestre, 2014). Misconception is the leading cause of students' difficulties since it is hard to be changed (Sencar & Eryilmaz, 2004; Hung & Jonassen, 2006; Stylos et al., 2008; Docktor &

Mestre, 2014; Widarti et al., 2016) and it would interfere with students' construction of new knowledge (Osborne et al., 1983; Turányi & Tóth, 2013). On the other hand, physics consists of a hierarchy set of knowledge, so according to the theory of constructivism, understanding of the prerequisite knowledge is necessarily to comprehend new concepts. Therefore, when designing a physics lesson teachers need to be aware to students' misconceptions and the concepts that students tend to be difficult to understand.

Many studies have uncovered students misconceptions and difficulties in many branches of physics. In mechanics, for instance, most students face difficulties on one-dimensional motion (Trowbridge & McDermott, 1980; Trowbridge & McDermott, 1981; McDermott et al., 1987), Newton's law (Halloun & Hestenes, 1985; Thornton & Sokoloff, 1998; Brown, 1989; Demirci, 2008; Rosenblatt & Heckler, 2011; Elmehd et al., 2013), rotational dynamic (López, 2003; Ortiz, 2005; Oliveira, 2011), conservation of energy

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(Dalaklioglu et al., 2015), and fluid mechanics (Besson, 2004; Loverude et al., 2010; Wijaya et al., 2016), mechanical wave propagation (Sutopo, 2016) and reflection (Kryjevskaja et al., 2011; Kryjevskaja et al., 2012). In thermodynamics, students tend to confuse temperature with heat (Gönen & Kocakaya, 2010; Alwan, 2011) and fail to apply state equation of ideal gas in problem solving (Kautz et al., 2005). In electricity, students' difficulties deal with electricity circuits (Stetetz et al., 2013) and Ohm's law (Vreeland, 2002; Sencar & Eryilmaz, 2004). Those findings show that there are still many misconceptions and difficulties faced by students in many branches of physics. Furthermore, the abundance of research revealing common student difficulty suggests that information about students' misconception and difficulties is very important in physics education.

Newtonian mechanics is a branch of physics that underlies almost all other branches of physics. Thus, it is important for students to grasp concepts and principles in Newtonian mechanics. Students' success in mastering Newtonian mechanics determines their success in learning other branches of physics (Hestenes & Well, 1992). The basic law in Newtonian mechanics is Newton's laws of motion. However, students need to grasp robust understanding of its derived laws as well, i.e. work-energy theorem and impulse-momentum theorem.

One of derived laws in Newtonian mechanics is impulse-momentum theorem (Hestenes, 1987). This theorem is highly useful to solve mechanic problems which involve force acting over an interval of time or changing with time (Serway & Jewett, 2014). Therefore, in addition to Newton's laws of motion, students need to meaningfully understand the theorem of impulse and momentum.

Some researchers have revealed students difficulties about impulse and momentum. Lawson & McDermott (1987) and Pride et al. (1998) found students misconceptions about the relationship between impulse and momentum. Graham & Berry (1996) revealed that most of 17-18 years old students think of momentum as scalar quantity. Singh & Rosengrant (2003) and Close & Heron (2010) found that most university students also think of momentum as scalar. Other researchers found students difficulties in applying conservation of momentum on collision problems (Bryce & MacMillan, 2009). Students believed that the conservation of momentum hold for each colliding objects, not for the system consisting of those objects (Ivowi, 1986).

This article is aimed to expose common

difficulties encountered by Indonesian students in solving problems related to the topics of impulse and momentum. The findings of this study are expected to provide new information about students' difficulties on impulse and momentum.

## METHODS

This research was a descriptive study using a survey technique. The subjects of this research were 175 students of a public senior high school in Malang who had learned impulse and momentum. They consisted of 70 students of grade XI who recently learned about impulse and momentum and 105 students of grade XII who relearned the topic for national examination preparation.

The data were collected by using a test as an instrument to measure students' levels of conceptual understanding on the impulse and momentum concepts that were based on standard competence of such topic stipulated in the 2013 curriculum. This test was given in the form of reasoned multiple choice complemented by a confidence rating scale consisting of 12 questions, which include 2 questions about momentum change, 4 questions about impulse-momentum theorem, and 6 questions about momentum conservation. However, based on the reasons given by the students for their answers, there were only 4 questions from each subtopic that require a further study regarding their difficulties. Therefore, this article would only discuss those 4 questions. Some questions given in the test were resulted from the modification of some standardized tests, namely Force Concept Inventory (Hestenes et al., 1992) and Energy and Momentum Concept Survey (Singh & Rosengrant, 2003).

The data analysis was done based on the students' answers to the test of impulse and momentum concepts mastery. In each question, students were asked to choose one correct answer from the given multiple choices, write down the reasons for their answers, and determine their confidence level about the answers. The reasons were used to reveal the students' way of thinking in solving the problems related to impulse and momentum. The students' certainty level about their answers was measured by using a Likert scale ranging from 0 to 3. 0 meant very unsure (only guessing), 1 meant less sure/sure enough, and 3 meant extremely sure about the answer. The levels of students' understanding would be categorized based on their answers and their certainty levels. This analysis method that is also known as Certainty of Response Index (CRI) had been done by some researchers, e.g. Hasan et al. (1999)



and Potgieter et al. (2010). The method used for the analysis of students' understanding level in this research referred to the method employed by Sutopo (2016) who adapted the method utilized by Potgieter et al. (2010). Based on their answers, the levels of students understanding were grouped into 4 categories. First, students who answered correctly with a certainty level of 3 would be considered to have a good knowledge of the concepts. Second, students who answered correctly with a certainty level of 2 would be deemed to have enough understanding of the concepts. Third, students who answered correctly with certainty level 1 or 0, or students who answered incorrectly with a certainty level of 2, 1, or 0 would be considered to have a low understanding of the concepts. Lastly, students who answered incorrectly with a certainty level of 3 would be deemed to have misconceptions.



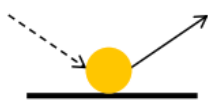





## RESULTS AND DISCUSSION

### Students' Difficulties in Solving Change of Momentum's Problems

Two questions illustrated in Figure 1a and 1b were used to identify the students' ability in solving change of momentum's problems. Both of the questions used the same principle of physics, but the contexts and representation forms were different. The question in figure 1a was presented in a mathematic-quantitative form in the context of one-dimensional motion in which a trolley changed its motion as a result of a collision with the wall. The question in figure 1b was presented in diagram and symbol in which a ball changes its motion in a collision with the floor. The distribution of students' answers and the level of students' understanding of the question in Figure 1a are completely presented in Table 1,

while the distribution of students' answers and the level of students' understanding of the question in Figure 1b are completely presented in Table 2.

Based on the reasons given by the students for their answers to the question in Figure 1a, it was shown that all students had understood that momentum was a vector identified as a result of the addition of an object's mass and its speed. Nevertheless, the students found difficulties in determining the change of momentum when the object changed its motion. Students' difficulties were encountered more frequently when they were trying to solve the question in Figure 1b than the question in Figure 1a. 54.29 % students answered the question presented in Figure 1a correctly (Table 1), whereas only 15.43 % students could respond to the question in Figure 1b correctly (Table 2). It showed that it is easier for the students to solve a question presented in a mathematic-quantitative form than the one presented in diagram and symbol forms (Torigoe, 2008; Docktor & Mestre, 2014). The detailed explanations on the students' difficulties in solving both questions are presented below. For the question in Figure 1a, although 95 students answered correctly, i.e. the option D, there were only 51 students who were certain about their answers. Most of the students who answered properly and were certain about their answers wrote down the equation of  $\Delta p = p_2 - p_1$  as their reasons. On the other hand, students who were not certain with their answers mostly wrote  $10 - (-20) = 30$  as their reasons. The students who answered A did not understand that a momentum change is the object momentum after collision reduced by the object momentum before collision so that students used the formula of  $\Delta p = (-20) - 10 = -30$ . However, there were not many students faced such problem (Table 1). Stu-

<p>A trolley with a mass of 10 kg is moving to the left; then it suddenly collides with a wall and moves to the right as the picture below shows:</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>before</p>  </div> <div style="text-align: center;"> <p>after</p>  </div> </div> <p>The momentum change the trolley has is ...</p> <p>A. 30 kg.m/s to the left          B. 10 kg.m/s to the left          C. 10 kg.m/s to the right          D. 30 kg.m/s to the right</p> <p style="text-align: right;">a)</p>	<p>A tennis ball collides with a table as illustrated in the picture below:</p>  <p>If the arrow with a pecked line represents the speed before the collision and the arrow with full line represent the speed after the collision, which arrow of the following is directing to the momentum change of the tennis ball if the direction before and after the collision is the same?</p> <p>A.  B.  C.  D.  E. </p> <p style="text-align: right;">b)</p>
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**Figure 1.** Questions to identify students' difficulties in determining momentum change in the forms of a) mathematic-quantitative, and b) diagram and symbol

**Table 1.** Students' Answer Distribution and Students' Levels of Conceptual Understanding about the question in Figure 1a

Choices	Answer Distribution				Understanding Level Distribution			
	Total number of Students		Students with the Indication of misconception		Understanding level	Code	N	%
	N	%	N	%				
A	9	5.14	5	2.86	High	SB	51	29.14
B	45	25.71	28	16.00	Misconception	M	43	24.57
C	24	13.71	10	5.71	Enough	C	34	19.43
D*	95	54.29	-	-	Low	L	45	25.71
NA	2	1.14	-	-	Unidentified	NA	2	1.14
Total	175	100	43	24.57	Total		175	100

\* choices of correct answer

**Table 2.** Distribution of Students' Answers and Levels of Conceptual Understanding about the question in Figure 1b

Choice	Answer distribution				Understanding Level Distribution			
	Total number of Students		Students with the Indication of misconception		Understanding level	Code	N	%
	N	%	N	%				
A*	27	15.43	-	-	High	SB	8	4.57
B	6	3.43	3	1.71	Misconception	M	44	25.14
C	9	5.14	1	0.57	Enough	C	10	5.71
D	54	30.86	24	13.71	Low	L	105	60.00
E	71	40.57	16	9.14	Unidentified	NA	8	4.57
NA	8	4.57	-	-				
Total	175	100	44	25.14	Total		175	100

\* choices of correct answer

dents who answered B did not understand that a vector equation is used to determine momentum change, so they only calculated the value of its momentum without paying attention to its direction so that students performed the calculation by using the formula of  $\Delta p = 10 - 20 = -10$ . This problem was the mostly faced difficulty by the students compared with the other problems (Table 1). It is relevant to the results of the research conducted by Graham & Berry (1996) who stated that students have problems in understanding the momentum concept as a vector. The students who answered C faced multi difficulties, namely the difficulties faced by students who answered A and B respectively. They did not understand that a vector addition is used in determining a momentum change and they were also wrong in formulating the momentum change. Those students performed the calculation by using the formula of  $\Delta p = 20 - 10 = 10$ . Besides, the students who answered C also assumed that the momen-

tum change was similar with the last momentum experienced by the trolley.

Most of the difficulties faced by the students in solving the question in figure 1b were caused by their problems in depicting the vector reduction by using the polygon method. Most students chose the option E for this question (Table 2) for several reasons. First, the students moved the  $p_2$  nucleus to  $p_1$  tip (Figure 2a). Second, the students related the  $p_1$  nucleus to the  $p_2$  tip (Figure 2b). Third, the students moved  $p_1$  nucleus to the  $p_2$  tip, and then connected the  $p_1$  tip to  $p_2$  nucleus (Figure 2c). Students who answered B gave the correct answer by reversing the  $p_1$  direction and moving the  $p_1$  nucleus to the  $p_2$  tip, but they made a mistake in determining the vector resultant by connecting the  $p_1$  tip to the  $p_2$  nucleus (Figure 2d). Figure 2a identified that the students could already describe a vector addition, but they found difficulties in describing a vector reduction. Besides, it might be because they did not understand

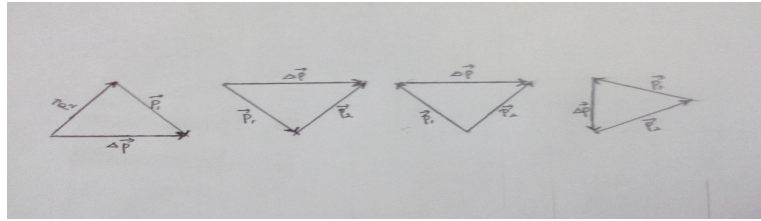


Figure 2. Examples of diagrams made by the students to solve the question in Picture 1b

Block A and B are pushed by the same constant force ( $F$ ) until both of the blocks reach the finish line. Initially, the two blocks are still and block A mass is twice bigger than that of block B.

The momentum comparison of both blocks when reaching the finish line is . . .

- $p_A = \frac{1}{2} p_B$
- $p_A = p_B$
- $p_A = 2 p_B$
- $p_A = \frac{1}{2} \sqrt{2} p_B$
- $p_A = \sqrt{2} p_B$

Figure 3. Question to Identify Students' difficulties related to Impulse-Momentum Theorem.

that a momentum change was a vector reduction. Figure 2b identified that the students had zero understanding about the determination of vector by using the polygon method. Figure 2c and 2d identified that the students already understood that a momentum change was a vector reduction so that they reversed the  $p_1$  direction, but they did not use the polygon method correctly. The high number of students who answered this question incorrectly identified that students had problems of two-dimensional vector reduction and interpreting the value and direction of a vector in the form of graph. Such facts were relevant to Nguyen & Meltzer (2003) and Wutchana & Emarat (2011) research results. The question shown in figure 1b indicated that students also have difficulties when they were given problems related to other topics that they had studied before (Berek et al., 2016).

On the other side, there were also students who gave wrong answers because they assumed that a momentum change was similar with the last momentum experienced by an object. Those students answered D for the question in Figure 1b because the direction was the same as the final momentum direction. Such assumption was made by a relatively high number of students (Table 2). Some students who answered D for the question in Figure 1b also answered C for the

question in Figure 1a based on the same reason. The students' consistency showed that they have a common misconception. Such thought of students needed the most attention and needed to be changed in learning physics.

### Students' difficulties Related to the Impulse-Momentum Theorem

In fact, based on the students' answers to the questions that include a mass of an object, initial and terminal velocities of an object, and the time interval of the collision, it was found that they had understood the relation between impulse and momentum in the form of  $I = \Delta p$  equation. In relation with those questions, the students, having the plug and chug tendency, could answer correctly when they were asked about the average forces acting on an object. It was possible because the variables needed to answer the questions were already given in the questions to be substituted into the equation of  $I = \Delta p$ . Therefore, when they had those variables, they could directly choose the correct equation (Walsh et al., 2007; Ding, 2011).

However, they could not activate their memory about the relation between impulse and momentum when they were given the question shown Figure 3. It revealed that students who know a mathematic equation are not guaranteed

to be able to apply such equation in physics (Sutopo, 2016). As a consequence, many students were wrong in answering questions of which contexts do not directly provide all variables to be substituted into the equation. In this research, no one could answer correctly to such kind of question. The distribution of the students' answers and students' conceptual understanding levels about the question shown in Figure 3 are completely presented in Table 3.

Most students answered options A and C when they did the question shown in Figure 3 (Table 3). On the other hand, the students who answered option C had a tendency to think that an object with a bigger mass has a bigger momentum. The question in Figure 3 informs that block A mass is twice larger than that of block B, so the students assumed that block A momentum was also twice as significant than that of block B. In contrast, students who answered A thought that the faster an object moves, the bigger the momentum of such object would be. Since the question in Figure 3 informing that a similar force act on both block A and B with block A mass that is twice bigger than that of block B, students could conclude that the velocity of block A was half of the block B velocity, so block A had a half momentum of the block B momentum. Students who answered A and C were not likely to be a lack of understanding that a momentum is a result of timing the mass and velocity of an object, so both of the mass and velocity values of an object influence its momentum. However, the students failed to activate such understanding since they had another dominant thought while solving the question in such context (Itza-Ortiz et al., 2004; Hrepic et al., 2010; Khasanah et al., 2016). Such issue needed to be paid attention and changed in physics learning.

To such kind of question, 2 students answered D (Table 3) could complete the questions in more appropriate steps. They searched for the velocity comparison by using the equation of  $v_A : v_B = \sqrt{(2a_A s)} : \sqrt{(2a_B s)} = \sqrt{(a_A)} : \sqrt{(a_B)} = \sqrt{(F/m_A)} : \sqrt{(F/m_B)}$  then they compared  $p_A : p_B = m_A v_A : m_B v_B$ . Unfortunately, they determined the comparison of block A momentum in the way they should determine the comparison of block B momentum, and vice versa.

### Students Difficulties Related to the Momentum Conservation Law

The application of  $m_1 v_1 + m_2 v_2 = m_1 v'_1 + m_2 v'_2$  equation of momentum conservation law by the students in solving a problem related to collision (a discovery from question that is not discussed in this article) does not guarantee that they know that they should use the law since zero force resultant acts when the collision happens. They did not understand that a force acting in this system was the action and reaction that had the same values but opposite directions. The finding was obtained based on the students' answers for the question presented in Figure 4. Only 2.29 % students could answer correctly to this question. The distributions of the students' answers and conceptual understanding levels of the question shown in Figure 4 are completely presented in Table 4.

Most students answered B and D while doing the question in Figure 4 (Table 4). Students who answered B assumed that force is a pushing or pulling movement, so only an object which is pushing or pulling has force. When the question informed that student A pushes student B, the students concluded that it is only student A who gives force. Students who answered D had some thoughts, including an object with bigger

**Table 3.** Students' Answer Distribution and Conceptual Understanding Level about the Question in Figure 3

Choices	Answer Distribution				Understanding Level Distribution			
	Total Number of Students		Students with the Indication of misconception		Understanding Level	Code	N	%
	N	%	N	%				
A	69	39.43	26	14.86	High	SB	0	0.00
B	7	4.00	3	1.71	Misconception	M	85	48.57
C	96	54.86	54	30.86	Enough	C	0	0.00
D	2	1.14	2	1.14	Low	L	89	50.86
E*	0	0.00	-	-	Unidentified	NA	1	0.57
NA	1	0.57	-	-				
Total	175	100	85	48.57	Total		175	100

\* choices of correct answer



Look at the picture!

Student A has 65 kg mass, and student B has 50 kg mass. They are sitting facing each other on two identical chairs. Student A then pushes student B with his feet as shown in the picture, which causes the chairs they are sitting to move.

Which statement is correct about the force acting during the interaction between student A and B?

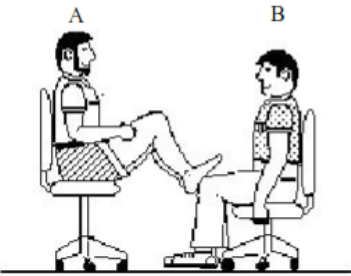
A. Both students do not give any force to each other

B. Student A gives force to student B. However, student B does not give any force at all

C. Every student gives force with each other, but the force from student B is bigger than the force from student A

D. Every student gives force to each other, but the force from student A is bigger than the force from student B

E. Every student gives the same force to each other.



**Figure 4.** Question to reveal Students’ Difficulties in Understanding Momentum Conservation Law.

**Table 4.** Distributions of students’ answers and conceptual understanding levels about the question in Figure 4

Choice	Answer Distribution				Understanding Level Distribution			
	Total Number of Students		Students with the Indication of misconception		Understanding Level	Code	N	%
	N	%	N	%				
A	0	0.00	0	0.00	High	SB	3	1.71
B	54	30.86	17	9.71	Misconception	M	51	29.14
C	9	5.14	5	2.86	Enough	C	0	0.00
D	99	56.57	29	16.57	Low	L	112	64,00
E*	4	2.29	-	-	Unidentified	NA	9	5.14
NA	9	5.14	-	-				
Total	175	100	51	29.14	Total		175	100

\* choices of correct answer

mass, gives a bigger force, so they assumed that force done by student A weighing 65 kg was larger than that done by student B weighing 50 kg. Also, an object which pushes/pulls gives a bigger force than an object which receives the force, so the force done by student A is larger because student A is the one pushing student B. In solving such question, the students faced difficulties in understanding that if two objects interact with each other, each object will give the same force but with opposite directions (Brown, 1989; Sayre et al., 2012). However, it did not mean that they did not understand about the action-reaction force of  $F_{\text{action}} = -F_{\text{reaction}}$ . Similar with the way the students answered the question in Figure 3, they used more dominant knowledge in their thought while answering the question in Figure 4 (Itza-Ortiz, et al., 2004; Hrepic et al., 2010; Khasanah et al., 2016).

The problems above would result in other mistakes done by the students, such as their difficulties in understanding that in a collision, the total momentum value is the conserved one, not the momentum value of each object colliding

with each other. It can be seen from the students’ answers for a question related to “a white marble collides with a red marble that is motionless, and after the collision, the white marble and the red marble move in the same direction but at different speeds.” When they were asked to determine the correct statement, most of them chose the statement that only the white marble which was conserved, and not both the white and red marbles. It was relevant to the results of research done by Singh & Rosengrant (2003) who found a students’ assumption that momentum conservation was the momentum of each object colliding with each other. Thus, students needed to understand well the situation in which the momentum conservation can be applied by reviewing the resultant acting in one object rather than the resultant force serving in the whole system. It could help students to understand that by reviewing the system, the force resultant becomes zero. In other words, the impulse acting on the system is zero, so the momentum change is equal to zero. It means there are not any changes in the momentum value before and after the collision.

## CONCLUSION

Most students get difficulties in solving impulse and momentum problems. It was because they failed to activate their appropriate concepts relevant to the problem. Students' difficulties were not only caused by their deficient conceptual understanding about impulse and momentum, but also their weak understanding about the relationship among force, acceleration, and velocity. Another difficulty was due to their deficient skill to work with vector. Representation format of the problem also contributed to students' difficulty. Students' performance in solving problem that is presented in mathematic-quantitative representation is better than that presented in diagram or figure representation.

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## IMPROVING THE VISUAL-SPATIAL INTELLIGENCE AND RESULTS OF LEARNING OF JUNIOR HIGH SCHOOL STUDENTS' WITH MULTIPLE INTELLIGENCES-BASED STUDENTS WORKSHEET LEARNING ON LENS MATERIALS

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### ABSTRACT

This research is done for the development of students' worksheet (LKPD) about multiple intelligences-based lens materials for improving the students' visual-spatial intelligence and results of learning of SMP N 2 Banda Aceh. This research uses a quasi-experimental design with pretest and posttest group. The sampling was done by purposive sampling technique. The data collection was conducted with pretest and posttest for visual-spatial intelligence and learning outcomes. The questionnaire was used to determine the response of students after using students' worksheet based on multiple bits of intelligence. The results of normality and homogeneity test show that the data was homogen and normally distributed. Therefore, the average difference test against the N-gain visual-spatial intelligence and learning outcomes between the two classes used t test and obtained a significant difference in learning outcomes between the two classes. The average score of the N-gain visual-spatial intelligence and learning outcomes for both classes was in the middle category, where the experimental class is 0.65 (65%), while for class gained control is 0.46 (46%). Learners gave a positive response to the use of multiple intelligences-based students' worksheet dealing with lens materials that can enhance their visual-spatial intelligence and learning outcomes.

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**Keywords:** students' worksheet; multiple bits of intelligence; visual-spatial; learning outcomes

### INTRODUCTION

Natural science education as one of the lessons that are usually learned by mathematical approach tends to be worried by the students. There are two intelligence standards used in the school for assessing students. They are linguistic intelligence and mathematic logics. In the learning process, teachers sometimes forget the eight kinds of intelligence so called multiple bits of intelligence (MI). According to Delgoshaei & Delavari (2012), inside a child's self, there is intelligence which can be more dominant than other intelligence. So, the child can easily understand the materials if the learning and teaching are done

by considering the intelligence. Many students' failures in understanding the materials from the teacher caused by the teachers' inappropriate teaching style with the students' learning style. A person's intelligence inclination reflects his/her learning style. This makes the students unable to give a positive response in natural science teaching and give effects to the lowness of learning outcomes (Wibowo & Suhandi, 2013).

According to the studies done by some researchers, teachers have tried best to teach all natural science materials, but there are some things missed, for example in visualizing the abstract of natural science concepts to the students. The available student's worksheet cannot help them in understanding those concepts because it only contains fewer materials and tasks. This kind of

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worksheet does not help students much in their intelligence. In line with it, after this study is done, some images are obtained that the students in SMP N 2 Banda Aceh have various kinds of intelligence. This finding can be a foundation of teaching media development that can improve the students' learning style and their intelligence. Armstrong (2004) asserted that students in every class have different skills (intelligence, talent, understanding speed). Teachers should pay attention at the students' intelligence besides paying attention to the materials.

Generally, students find themselves in a problem in learning natural science, especially in lens materials. Their difficulty is in differentiating kinds of lens and kinds of lens' shadows. Besides, students felt difficult in understanding the formulas dealing with lens and applying them in exercises. The students' weakness in mathematical skills automatically affects in natural science understanding. Sometimes, students cannot finish the tasks completely because they cannot understand or memorize the basic concept of natural science they ever learned. Moreover, their intelligence does get betterment. It means that the students who have intelligence in number and logic who can understand natural science materials well. This is the thing that affects the lowness of students' learning outcomes. It is known from National Examination (UN) data in 2013/2014 that the materials to determine light disposition related to mirror or lens or optic usage in daily life are lower than other natural science materials in 43.08.

This proves that there are many students who are not able to understand the concept of the lens. Considering the importance of this concept, it is important to present a better teaching method to motivate and provide the students in developing and increasing visual-spatial intelligence and their learning outcomes. One of the possible learning strategies developed to improve visual-spatial intelligence and learning outcomes in lens materials is the development of MI-based students' worksheet. Learning with MI is planning a series of learning activities designed by adjusting the students' intelligence. Gardner asserts that there are eight types of intelligence: linguistic intelligence, mathematics-logic, visual-spatial, musical, naturalist, intrapersonal, interpersonal and kinaesthetic (Sulaiman, et al., 2011; Ahvan dan Pour, 2016).

According to Wijayanti & Arif (2015), the development of IP-based LKS MI is based on the five dominant bits of intelligence of students, namely logical-mathematical intelligence,

physical-kinesthetic intelligence, visual-spatial intelligence, interpersonal intelligence, and existential-spiritual intelligence is feasible and effective use as a teaching material for junior high school students. Furthermore, Rizal (2012) explained that the development of MI-based students' worksheet on optical tool materials could improve students' learning outcomes with an average value of 85.8 with a percentage of 81% completeness. Then for total response interest of the student to LKS MI equal to 90,6%. Similarly, the research results Maulidah and Agus (2012) found that the constructive game given as a treatment to learners can improve their spatial-visual and interpersonal intelligence. In addition, MI-based students' worksheet development received an excellent assessment from all assessors overallly got a moderate improvement with N-gain of 0.58 and students also responded well, meaning this students' worksheet was acceptable. Based on the explanation above, it is necessary to develop teaching materials that can improve visual-spatial intelligence and natural science learning outcomes, one of which is with MI-based students' worksheet. Through this students' worksheet, the students will easily understand the learning materials, so the results will be more useful for them in their environment.

## METHODS

The method used in this research is research and development (R & D) to identify students' intelligence and teaching materials needs in SMP N 2 Banda Aceh through the development of MI-based students' worksheet. The R & D method is a research approach to produce new products or refine existing products. The research design used was quasi-experimental. The study was conducted in three stages: (1) pretest, (2) learning implementation using MI-based students' worksheet for experimental class and students' worksheet without MI without pictures for control class, (3) posttest.

The population in this study is all students of class VIII SMP N 2 Banda Aceh which consists of 224 students. The sample of the study consists of students of class VIII-2 and VIII-3 selected by purposive sampling technique based on certain inputs and considerations from the science teachers who taught in the classes. Class VIII-3 consists of 27 students as an experimental class, and VIII-2 consists of 25 students as control class. The data collection used five types of instruments, namely the tasks for the test, students' worksheet validation sheet, spiritual and

social attitudes observation, test to determine the dominant intelligence of each student, and questionnaire for the students. Tasks to measure visual-spatial intelligence and students' learning outcomes on lens materials both before and after learning in the class. The data analysis of pretest, posttest, and questionnaire results of learners' learning on learning used MI-based students' worksheet.

## RESULTS AND DISCUSSION

### MI-based Students' Worksheet

In the MI-based learning process, the first step taken is to conduct the intelligence test. The test is done in both classes to find out the dominant intelligence the learners have based on the questionnaire that has been shared. In the analysis phase, to determine the MI, each learner selected three types of intelligence with the highest score. In the process of data analysis, it is found that some learners have the same score on some types of intelligence. Especially for this situation, researchers determine the four dominant bits of intelligence. The students' dominant intelligence is summed and then calculated with the percentage so the intelligence that dominates most in the class is obtained.

### Results of Visual-Spatial Intelligence and Students' Learning Outcomes

Results of visual-spatial intelligence and students' learning outcomes on lens materials were measured by multiple choice tests consisting of 13 questions. The data comparison is the mean values of pretest, posttest, and N-gain (in percent) between the experimental class and the control class. The percentage comparison diagram of the average score of pretest, posttest, and N-gain between the control class and the experimental class is shown in Figure 1.

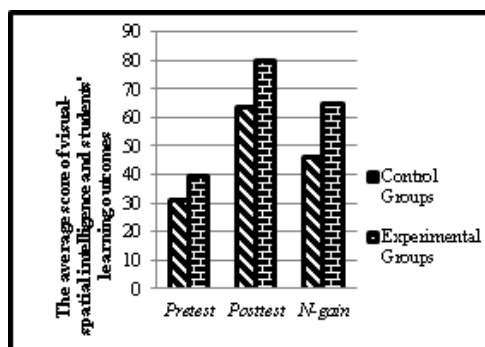


Figure 1. Average score comparison of *pretest*, *posttest*, dan *N-gain*

Figure 1 shows the percentage of the mean value of pretest result of the experimental class of 39.87 and the control class 31.06. Furthermore, the percentage of posttest average value in the experimental class is 80.04, and the control class is 63.67. N-gain of visual spatial intelligence score and experimental class learning outcome is 65 and control class is 46. The N-gain average score of a control class and experimental class is in medium category although the N-gain of the experimental class is higher than the control class. Individually reviewed, the experimental class is better than the control class. Individual N-gain ratio of students can be seen in Figure 2.

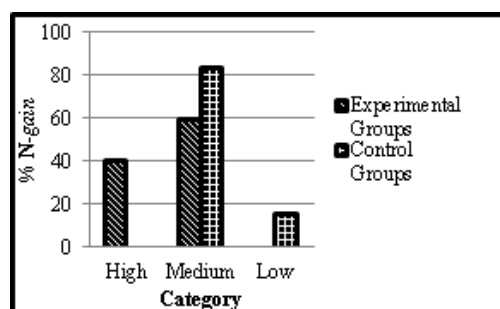


Figure 2. Individual N-gain percentage comparison.

Figure 2 shows that the percentage of normalized N-gain individually in the experimental class is categorized in a high category with 11 students (40.74%), the medium category is 16 students (59.25%), and there is no low N-gain in the experimental class. In the control class, there is no high category for N-gain. The moderate category consists of 21 students (84%), and low category consists of 4 students (16%). Furthermore, the normality test of the distribution and homogeneity of visual-spatial intelligence data and learning outcomes on the lens materials of experimental class and experimental class were performed by Lilifors test using using Ms. Excel 2010 at 0.05 significance level. Based on the pretest, posttest, and N-gain values of both classes, it is known that the data are normally distributed and homogeneous. The t-test results using independent sample test are presented in Table 1.

Based on the data in Table 1, it is known that the pretest score in two classes with  $t_{\text{count}} = 1.80$  is smaller than the  $t_{\text{table}} = 2.01$  with the significance level  $< 0.05$ . It can be concluded that there is no significant difference before the learning process using MI-based students' worksheet. The posttest score is obtained from  $t_{\text{count}} > t_{\text{table}}$  ( $6,90 > 2,01$ ) that shows there is an increase in visual-spatial intelligence after given a treatment

**Table 1.** Visual-spatial intelligence and learning outcomes average difference test on lens materials

Data Source	Class	Average	Deviation Standard	$t_{\text{count}}$	$t_{\text{table}}$	Conclusion
Pretest	Experimental	39,87	19,20	1,80	2,01	The difference is not significant
	Control	31,06	16,20			
Posttest	Experimental	80,04	8,32	6,90	2,01	The difference is significant
	Control	63,67	8,74			
N-gain	Experimental	0,65	0,16	3,10	2,01	The difference is significant
	Control	0,46	0,13			

**Table 2.** Students' visual-spatial intelligence and learning outcomes test score.

Visual-Spatial Intelligence Indicator	Class Score Indicator	
	Experimental	Control
Having the sensitivity to colors, lines, shapes, spaces, and buildings.	78,70	74
Having the ability to form useful things.	85,18	56
Having the ability to visualize something, create ideas visually and spatially (in the form of pictures or visible things).	79,36	58
Having the ability to recognize object's identity from different angles.	85,18	64

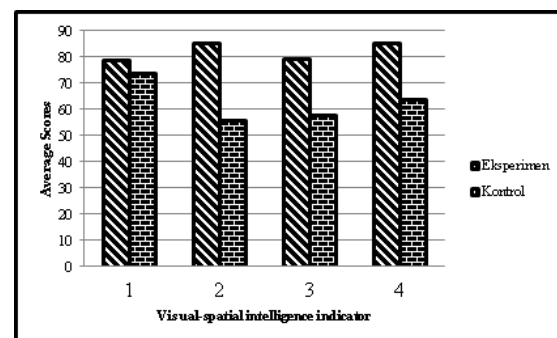
using MI-based students' worksheet. After that, the N-gain is obtained from  $t_{\text{count}} > t_{\text{table}}$  ( $3,10 > 2,01$ ) that shows that there is an increase of visual-spatial intelligence and learning outcomes of students who got a teaching with students' worksheet which is higher than the learning process in control class. The results of the data analysis above show that MI-based students' worksheet significantly influences the improvement of students' visual-spatial intelligence and learning outcomes after being treated.

### Students' Skill Based on Visual-Spatial and Learning Outcomes Indicator

The data of visual-spatial intelligence and learning outcomes of experimental class and control class learners were obtained by providing pretest and posttest using four visual-spatial intelligence indicators and learning outcomes developed into 13 questions. The tests were conducted in both experimental and control class. The average value data for each indicator is illustrated in Table 2 and Figure 3.

Based on the data of Table 2 and Figure 3, the level of visual-spatial intelligence and students' learning outcomes in lens material with four indicators representing each concept has improved on all indicators. The experimental class students' score is higher than the control class. The average score of experiments are based on the order of the high score to the low, i.e., 1) having the ability to form useful things, 2) having the ability to recognize the object's identity from

different angles, 3) having the ability to visualize something, create ideas visually and spatially (in the form of pictures or visible things), 4) having the sensitivity to colors, lines, shapes, spaces, and buildings. Seen from these results, the students' learning outcomes can be known by looking at the results of changes that occur in the students' ability. The results can be seen from the achievement of visual-spatial intelligence and learning outcomes test that have been conducted.

**Figure 3.** Visual-spatial and learning outcomes average score.

The analysis of the observation data of learning activities with students' worksheet shows that learning with students' worksheet can be done well. The students follow every step of the learning activities diligently and passionately during the learning process. All learning activities show that the learning process was done lively and well. Successful use of students' worksheet



by the students in learning is affected by students' worksheet because it contains teaching materials simpler than the model, but more complex than the lesson books. Besides it can improve visual-spatial intelligence and learning outcomes, MI-based students' worksheet also does not require students to get the same results in every aspect of assessment, but each aspect of the assessment is integrated to complement each other. So the students can grow in accordance with the skills they have. These results support the research conducted by Setyowati & Hinduan (2009) that says a student will easily understand the materials if the learning is done by paying attention to the intelligence of each student so that the learning outcomes can be better. Furthermore, it is also reinforced by research results of Arifah (2013) that says the provision of appropriate evaluation can optimize the intelligence the students have. The results of this study are also supported by Fitriyani (2014) which states that the increase of students' visual-spatial intelligence gets betterment after being given treatment. The same thing is also found in research conducted by Margaret and Gatot (2015) that says students with high visual-spatial intelligence are more prominent in the ability to visualize, present ideas visually and spatially, and orientate themselves appropriately in solving problems.

Students' attitudes were also observed by the observer during the learning process. The result of this value is used as an assessment of the students' attitudes. The observed attitudes in the form of social attitudes are responsibility, honesty, and caring, while the spiritual attitudes consist of praying before doing something, giving thanks and greeting. Zakarian (2014) stated that the 2013 curriculum emphasizes the development of the character and personality of students. The attitude competence here refers to the application of the values or students' world view and behavior. Marzuki (2012) stated that character education is not only about teaching students which one is right or wrong, but also teaching good behaviors and making them understand, do, and feel well.

Information is obtained from the observation result of social attitude assessment that the average value of the attitude of responsibility is the highest among other observed attitudes. This character enhancement is obtained because students always follow every direction and step in students' worksheet. This attitude is always instilled by students during the learning activities. Students can carry out their duties and responsibilities as they should and in accordance with

their skills and abilities, and not only expect other friends to complete the tasks (Cahyani, et al., 2014). They can participate in doing their tasks interpersonally and interpersonally. Students feel needed when they directly involve in conducting useful activities (Estrella, 2016). According to Welch (2010), students who are often involved in social activities will definitely understand what they will do in terms of establishing meaningful relationships. This is inline with the results of MI found in interpersonal intelligence (Safitri, et al., 2013). Furthermore, Aryani (2014) emphasize that interpersonal intelligence will train students to socialize with others, because in reality, in interaction with others is very important.

The observation results on the honesty attitude show that it increased and got betterment where the observed attitude assessment through the students' actions in completing tasks given by the teacher independently. The results of this study are in line with a study done by Jaya et al. (2014) which found the development of a learning tool by integrating the character values optimally in the learning activities can improve the attitude aspects students and improve. In addition, the use of MI approach indicates a positive effect of thematic teaching on MI on learning outcome and student's character. The average learning outcomes of the experimental group are higher than the control group. Significant positive correlation between spiritual intelligence and honesty values. Intelligence and character are important in education and can not be separated because intelligence character building are the main goals of education.

Observation on caring attitude shows that it also improves to betterment. Especially in the control class, students are constantly reminded to care and help each other during learning activities. The learning process that cultivates the aspects of caring can foster mutual help in doing positive things for students such as teaching a friend who has not understood the materials in the class. This is in line with a study conducted by Kalas (2013) that asserts the learning process that invites learners to be more active in discussing difficult concepts with their friends tends to be very effective in improving the quality of learning. The obtained feedback will be very useful in improving the quality of learning in accordance with the students' needs. It also happens to three other attitude assessments in the praying before doing anything, be thankful when you're done doing something, and greet before and after class or presentation altogether increased to betterment. This is inline with Munandar's (2015) assertion

that students' worksheet is able to contribute to the students' character formation.

Each process of learning activities with students' worksheet until the learning outcomes shows learning with it is in accordance with scientific and MI approach because in it there is a process of observing, asking, gathering information, processing, and communicating. This sequence is a process done by a scientist to gain knowledge and appreciate even the smallest intelligence that a student has.

### Students' Responses after Using MI-based Students' Worksheet

The result of questionnaire data processing shows that students mostly choose Yes answer than the No answer with the average value for Yes on the questionnaire is 98.14% while the answer No is 1.851%. The most active requirement of students' worksheet is the variation of stimulus through student-centered activities. The diction used in students' worksheet is easy to understand, and interesting presentation makes students' worksheet can be studied independently by students, but it can also arouse students' interest if neatly arranged, systematic, easy to understand, and interesting. This is inline with the results of Temur's (2007), and Xie & Lin (2009) studies dealing with the MI application in learning over traditional teaching methods. Thus, it can be concluded that using MI-based students' worksheet on lens material made 27 students gave positive responses.

### CONCLUSION

This result shows an increase in visual-spatial intelligence and learning outcomes for VIII students of SMP N 2 Banda Aceh on learning lens materials through learning using MI-based students' worksheet and gave a significant increase. In addition, the responses provided by the students were also positive after learning using MI-based students' worksheet on lens materials.

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## THE DEVELOPMENT OF LOCAL WISDOM-BASED NATURAL SCIENCE MODULE TO IMPROVE SCIENCE LITERATION OF STUDENTS

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### ABSTRACT

The vulnerability of communities in facing volcano disaster is one of the indicators of the low literacy of science. The low knowledge about volcanic material causes it needs to be packed in an attractive learning so that it can tap into the ability of students' science literacy by using teaching materials that are closer to student learning environments. This research aims to develop the local wisdom-based natural science module on the theme of Mount Kelud eruption, which is both theoretical and empirical. The type of this research development is Research and Development (R & D) by adapting the ASSURE instructional design. The results of this research are the validation results of theoretical feasibility of teaching materials based on the components of material feasibility of 87, 5% with very good category, components of presentation feasibility of 91, 7% with very good category, components of language feasibility of 88, 9% with very good category, components of local wisdom values of 87, 5% with very good category, and components of science literacy feasibility of 88, 9% with 88, 9% with very good category. The results of empirical feasibility are the test results of students' science literacy with N-gain variation value of 0,2; 0,3; and 0,4 respectively with low, medium, and medium category. The results show that the developed local wisdom-based natural science module is suitable to improve the ability of students' science literacy either theoretically or empirically.

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**Keywords:** natural science module; local wisdom; science literacy

### INTRODUCTION

The life of people in the globalization era is characterized by the rapidly growing progress of science and technology. It demands the citizen to have basic skills that can be used to socialize in the community. A competitive generation is needed in the natural science and technology referring to the ability of science literacy.

In the 21st century, science literacy becomes the focus of science education or natural science (Safitri et al., 2015), because the development level of a certain nation is determined by the awareness of human resources toward

science and technology (Genc, 2015; Jurecki & Wander, 2012; Holbrook & Rannikmäe, 2009; Turgut, 2007). In addition, Programme for International Student Assessment (PISA) defines literary science as the capacity to use scientific knowledge, identify questions, and draw conclusions based on evidence in order to understand and help in making decisions about daily life and interaction between human and nature (Bybee, 2011). Yuenyong and Narjaikaw (2009) define science literacy as knowledge toward science and understanding toward relation between sciences, technology, society, and environment. It shows that the students are hoped to be able to master the scientific knowledge and apply it in the daily life. Science for All American defines litera-

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ry science as an ability to understand concept, science principle, and scientific thinking to solve problems relating to science. An understanding of learning directing to the shaping of science literacy on students is apparently still lacking in Indonesia. It can be seen from the vulnerability of Indonesian citizens toward the threat of a volcano. According to (Safitri et al., 2015) that the ability of students' science literacy of Indonesia is still low. It is proven from the research results conducted by PISA (Programme for International Student Assessment) organized by PISA in 2012. The results stated that the ability of students' science literacy of Indonesia with the subject of fifteen-years-old students ranked 64th out of 65 participating countries that are below the PISA average standard is 500. The score result of science is only 382. In every three years, the ranking of Indonesia continues to decline. The decrease in science literacy skills is further strengthened by the low level of learners' knowledge of volcano-related problems.

This is also strengthened by Martin's research in Hariyono (2014), which shows that the average score of Indonesian students' ability in Earth Science material is 33, much lower than the international average of 45. The ability of science literacy for learners is important to master, considering that Indonesia is an archipelagic country located at the meeting of three major tectonic plates of the world, the Euro-Asia Plate in the North, the Indo-Australian Plate in the South and the Philippine-Pacific Ocean Plate in the East. This makes Indonesia be a country with high levels of vulnerability to natural disasters, one of which is volcanic eruptions.

Indonesia is a country that is located in the Ring of Fire because it is surrounded by a meeting of tectonic plates with an active volcano row. Indonesia has 127 active volcanoes comprising of 76 type A volcano, 30 type B volcanoes, and 21 type C volcanoes. Type A volcanoes are spread in several locations such as in East Java as many as 19 volcanoes, one of which is Mount Kelud, which is located between Kediri, Blitar, and Malang (Anwari, 2015). The eruption of Mount Kelud in 2014 caused the Ngantang District to be the most severely affected. This is because the Ngantang District is the closest area to Kelud Crater, which is about 7-10 km. The volcanic ash, which reaches the Ngantang District, has a thickness of 20-30 cm with a diameter of 5-8 cm (Syiko in Ma'arif et al., 2012). Until now, Mount Kelud is declared as an active volcano that is still possible to happen an eruption in the future. Knowledge of natural disasters needs to be held in disaster

prone areas, especially volcanoes.

SMP Negeri 1 Puncu is a school, which is located on the slopes of Mount Kelud, Kediri Regency. As a school vulnerable to a volcanic eruption, knowledge of volcano problems should be fully understood by students. The results of the dissemination of test sheets given to 28 Grade VIII-G students of SMP Negeri 1 Puncu indicate that all students have experienced an eruption of Mount Kelud, 38% of students know the cause of eruption, and 44% of students can explain the signs of the eruption of Mount correctly. From the students' answers, several problems were found, such as students assuming that the volcano erupted due to natural conditions and the mountains were old, the students still had difficulties in distinguishing lava and magma, and most of the students' answers were not accompanied by scientific explanations. Djulia in Sudarmin (2014) explained that the low literacy of science and the quality of education in Indonesia had been predicted because of the lack of attention to the socio-cultural environment as a source of learning.

The villagers on the slopes of Mount Kelud for generations have recognized the volcano activity. The area around Mount Kelud has local wisdom that appears and develops from generation to generation in the form of knowledge, customs, and ethics that guide the community in facing eruption disaster. One of the local wisdom that developed in the society is signs of the eruption of Mount Kelud. People believe that if there are a red-tailed ape and Turtledove birds "Gung" which go down to the residential areas, the eruption of Mount Kelud will happen. Ma'arif et al. (2012) concluded that each community group has knowledge and ways to deal with the environment for their survival. It is known as "wisdom to cope with the local events" or often abbreviated as "local wisdom." Based on the result of teacher interview, there is no teaching material describing the local wisdom of the local area.

Regulation of the Minister of National Education number 22 of 2006 which states that each educational unit can offer to learn in accordance with the interests and talents of learners as well as local potential, cultural environment, economic conditions and regional needs, with competence standards and basic competencies self-developed. Education Unit Level Curriculum provides schools and teachers the freedom to develop their own curriculum according to the needs and circumstances of the community around the school (Isnaini, 2013). Cultural-oriented learning (ethnosains) is based on the recognition of cultu-

re as a fundamental part of education to express and communicate an idea and the development of knowledge (Ryan, 2010). Atmojo (2012) has tried to meet the challenge, by making a science-based teaching design using ethnoscience approach through the cultural context of making soybean cake (*tempe*). Based on this, teachers are expected to develop lessons that can utilize local wisdom as a learning resource. Modules can be used as teaching materials that can connect knowledge of science with the local wisdom.

Sardjiyo (2005) states that the development of IPA learning media based on ethnosciences approach is a way to create a learning atmosphere and learning experience that integrates local wisdom in the process of science learning. This is in line with Khoiri (2016), he stated that learning that connects the context of local potential with learning materials would help the learner to achieve the learning objectives. Knowledge of local potential is closely linked to the learner's experience. Osborn (2003) explains that the learner experience or prior-knowledge will have a positive impact on the learning attitudes of science. In addition, learners who have had learning experiences related to local wisdom will tend to gain cognitive improvement because they are more motivated (Tosun and Taskesenligil, 2011). Sajidan et al. (2015) have also successfully implemented this kind of learning. The study showed that 85% of learners were able to connect to the concept of IPA and local knowledge in the community. Therefore, the researcher suggests that prospective IPA teachers should emphasize on the exploration skills of learning source, which derived from the socio-cultural environment to increase understanding of the IPA concepts.

Based on the open questionnaire, which is distributed to students of grade VIII-G SMP Negeri 1 Puncu, it is found that 43% of students want modules that contained information of everyday life. Learning resources using cultural and local wisdom approaches are expected to make learners to achieve established competencies. In addition, learners also obtain the more meaningful learning because it is close to the cultural environment.

The Aprilia's Research (2015) states that the booklet of ethnosciences (Indegenous Science and Local Wisdom) is worth theoretically to be used in the learning process on the diversity of matter, and the ability of science literacy, as well as Sudarmin & Samini (2015), states that the use of integrated module of ethnosciences in learning Problem-based is effective used for student literacy skills.

From the description above, then, it is conducted research and development of local-based wisdom IPA module by using the theme of Kelud Mount eruption to teach the science literacy towards students SMP Negeri 1 Puncu.

## METHODS

This research is using research and development (R & D) method by adapting the instructional design ASSURE. The development of IPA modules local wisdom -based is reviewed based on theoretical and empirical feasibility. The target of this research is IPA module based local wisdom. The development stage was conducted in major of S-1 IPA Education in Mathematics and Sciences Faculty (FMIPA) and limited trial at SMP Negeri 1 Puncu with 15 students of class VIII. The limited trial design is using One Group Pretest-Posttest Design. The data obtained in this research is the result of validation of local wisdom-based IPA module and the result of student's science literacy test.

The result of local wisdom IPA module validation was analyzed by quantitative descriptive. The analysis method used in the study as follows:

$$P = \frac{f}{N} \times 100\%$$

By the description of 'p' is the percentage of eligibility module, N is the maximum number of scores and f is the number of scores obtained. The local wisdom-based IPA module is considered to be deserved as a good category if the validation rating achieves  $\geq 69\%$  (Akbar, 2013).

A science literacy test of the student is used to measure students' literacy skills. To calculate the science literacy test scores of students using the formula as follow:

$$\text{Score} = \frac{\text{Total score of answers}}{\text{Maximum score}} \times 100\%$$

Then, the scores obtained are interpreted into science literacy level scores according to PISA (Yuliantika in Inzanah, 2014). The increasing of student science literacy was analyzed by normalized N-gain formula:

$$\text{N-gain} = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

With criteria of the gain score,  $g \geq 0.7$  is a high category,  $0.3 \leq g < 0.7$  is a medium category and  $g < 0.3$  is a low category.

## RESULTS AND DISCUSSION

The research entitled "The feasibility of Local Wisdom-based IPA Module to Improve Literacy of Student Science" has been implemented

and collected various data needed. Then, the data are analyzed to determine the feasibility of the modules applied in the learning as it is reviewed from the theoretical and empirical feasibility. The theoretical feasibility can be determined from the validation done by ethno sciences expert, lecturer as the expert of material, and science teacher. Empirical feasibility can be seen from the results of students' science literacy tests. The result of the feasibility of the module theoretically explained in Table 1 below.

**Table 1.** The theoretical feasibility of module

Component	Score (%)	Category
Material	87,5	Very good
Language	91,7	Very good
Presentation	88,9	Very good
Local wisdom	87,5	Very good
Science literacy	88,9	Very good

The development of local wisdom-based IPA module consists of five components. They are material feasibility, presentation, language, conformity with local wisdom values and their compatibility with science literacy. Based on Table 1, the local wisdom-based IPA module, the overall material feasibility component results in an average percentage of 87.5% with very good feasibility categories. The overall feasibility of the presentation results in an average percentage of 91.7% with very good feasibility categories. The overall language feasibility gets 88.9% percentage with very good feasibility category. The feasibility of conformity with local wisdom values as a whole gets an average percentage of 87.5% very good feasibility categories. The feasibility of conformity with the overall science literacy dimension gets an average percentage of 88.9% with very good feasibility categories.

The eligibility of the module theoretically gets an average of percentage score 88.9 with the good category. According to Rusilowati et al. (2016), she states that local wisdom-based IPA modules are considered to be appropriate as in good category if the validation assessment reaches 77%. Therefore, it can be said that the local wisdom-based IPA module developed is appropriate theoretically used in learning.

Scientific literacy capabilities measured includes the dimensions of content, context, and process. The test given is in the form of multiple choice questions amounted to 10 questions that oriented science literacy. The table 2 below is Pretest and Posttest results.

**Table 2.** Pretest and Posttest results

Science Literacy Level	Achievement Percentage		N-Gain	Criteria
	Pretest	Posttest		
2	80,0	6,7	-3,7	(Decreased)
3	13,3	26,7	0,2	Low
4	6,7	39,9	0,4	Medium
5	0	26,7	0,3	Medium

Based on Table 2, pretest results show 13.3% of students are in level 3 of science literacy ability, 6.7% of students are in level 4 of science literacy ability, and the remaining 80.0% are in level 2 of science literacy ability. After the implementation of learning by using local wisdom-based IPA module, the posttest result shows that the remaining 6.7% of students are in level 2 of science literacy ability. This result indicates that most students experience a change in literacy skills of science that initially in level 2 becomes to a higher level. Table 2 also shows 26.7% with science literacy ability of level 3, 39.9% of students with science literacy ability of level 4 and the remaining 26.7% of students are in science literacy ability of level 5. Improvement of science literacy can be made through improvement of the learning process (Sujana, et al., 2014).

Based on the results of the pretest from 15 students in Table 2, the large percentage is in the science literacy ability of level 2 (Fleischman et al., 2010) stated that at that level students have sufficient science knowledge to provide explanations or draw conclusions based on simple inquiry. Students are able to provide direct reasoning and make general interpretations of the results of scientific inquiry or problem solving from technological aspects. Posttest results show the largest percentage is at level 4. At these levels indicates that students can work effectively with situations and problems that may involve explicit phenomena. Therefore, it requires them to make inferences about the role of science and technology knowledge (Fleischman et al., 2010).

The results are quite satisfactory by seeing from the low of science literacy level achieved in Indonesia. PISA (2012) states that 22% of Indonesian students are at level 2 and only 2% are able to reach level 3 and above. The science literacy level of Indonesian students is in the second rank from the lowest level of PISA after Peru. The level achievement of students' science literacy ability between the PISA results and the limited trial results is different. This is due to the difference in standard questions given by PISA. In addi-

on, there are other factors such as the potential, regional characteristics, social and cultural communities and the diversity of Indonesia students. Those factors will certainly give effect to the aspects of learning and the ability of science literacy students. Inzanah (2013) states the results of science literacy can be different from PISA results if it is conducted in a smaller scope.

The ability of science literacy can be improved by taking into account the characteristics and potential of students, and the development of teaching materials, which is accordance with student learning environment. As Yusuf (2011) states that teaching materials can be obtained from supported sources of life-skills, authentic materials, and having a cultural value that is appropriate to the learning experience. This research is focusing on the development of teaching materials in the form of IPA module based local wisdom community of Mount Kelud. This is in line with Djulia's statement (Sudarmin, 2014), the low level of science literacy and the quality of education in Indonesia has been predicted because of the lack of attention to the socio-cultural environment as a source of learning. Therefore, it is required teaching materials in accordance with the socio-cultural environment of students. Parmin (2015) states that the development of culture in the community should be used as material in the development of teaching materials of IPA.

The development of student science literacy is seen from pretest and posttest score by using N-gain analysis. The result of N-gain analysis can be presented in Table 2, which is informing that the increase of science literacy result is in the low and medium category. The development of science literacy is not maximal because the teacher does not give more time in science literacy training. It means that it needs to add more time allocation in the science lesson to improve students' science literacy. Therefore, it can be used in future research. However, in the medium category, it can be seen that there is an increase in student science literacy. The local-based science wisdom of IPA learning can encourage students to construct and make connections between the knowledge and reality in the environment.

Local wisdom-based IPA modules can be developed by reconstructing origin science into western science or scientific science (Khusniati, 2014). An experiment activity is conducted based on the LKS that contained in local wisdom based module. The module of Mount Kelud Eruption is not only focusing on material content about Volcano Eruption, but also there is context dimension in the form of the local wisdom of people

around Kelud mount. The Student Worksheet (LKS) contained in the module is linked to the local wisdom values of the local community including public belief about the causes of erupting volcanoes, then, it is examined by performing simple experimental activities.

Through simple experiments, students can explain the scientific phenomenon, which is one of the indicators of process dimensions. In the module, there is also an LKS where students are assigned to explain the scientific science that is found in the local wisdom of the native people by using local wisdom IPA module. Therefore, students can answer the questions of pretest and posttest that required explaining the scientific science contained in local wisdom around student learning environment. This is similar to the statement of Holbrook (2005) that science will be easy to learn when it makes sense in the students' view and it relates to the human environment, interests, and aspirations. According to Sudarmin & Samini (2015), learning using an integrated module of ethno sciences in problem-based learning also provides an opportunity for students to involve directly and actively in scientific activities, and provide worth experience to students about IPA learning in the context of local wisdom. Therefore, the concepts received by students will be easy to remember. The students become more familiar with the material being studied. This is similar to the statement that expressed by Susilowati et al. (2014) maximum activity is generally followed by good learning results.

## CONCLUSION

Based on the results of the research above, it can conclude that local-based wisdom IPA module by using the theme of Mount Kelud eruption developed is feasible, theoretically and empirically. It is based on the suitability of the material feasibility component is 87.5% of the very good category. The feasibility of presentation is 91.7% of the very good category. The language feasibility component is 88.9% of the very good category. The local wisdom values component is 87.5% of the very good category. In addition, the science literacy feasibility component is 88.9% of the very good category. Based on result Student science literacy test with a value of the variation of N-gain 0,2; 0,3; And 0,4 respectively with low, medium, and moderate categories. The suggestions to this research are a module that has been developed is appropriate to used by science teacher of SMP as material to teach topics related to natural phenomena and ecosystem. It has a purpose of imp-



roving the skill of literacy of junior high school student.

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## THE EVALUATION OF SCIENCE LEARNING PROGRAM, TECHNOLOGY AND SOCIETY APPLICATION OF AUDIO BIO HARMONIC SYSTEM WITH SOLAR ENERGY TO IMPROVE CROP PRODUCTIVITY

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### ABSTRACT

One of the greatest challenges in science learning is how to integrate a wide range of basic scientific concepts of physics, chemistry, and biology into an integrated learning material. Research-based teaching material in this area is still very poor and does not much involve students of science education in its implementation as part of the learning program science technology and society (STS). The purpose of this study is to get the result of evaluation of the teaching and learning of STS in the form of public service in Kulon Progo, Yogyakarta. The program to improve crop productivity through the application of Audio Bio Harmonic System (ABHS) with solar energy have been selected for utilizing the natural animal sounds to open stomata of the leaves conducted during foliar fertilization, making it suitable for integrated science lessons. Component of evaluation model used is Stufflebeam model evaluation (CIPP). CIPP evaluation in these activities resulted in two aspects: The first aspect was improving the skills of students and farmers in using ABHS, and these two aspects, namely food crop productivity; (1) cayenne increased 76.4%, (2) increased red onions (56.3%) and (3) of maize increased by 67.8%. Besides, it was also the effect of the application of ABHS on the rate of plant growth. The outcome of this study is the STS teaching materials and appropriate technology of ABHS with solar energy.

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**Keywords:** evaluation; science technology and society; audio bioharmonic; crop productivity

### INTRODUCTION

Science learning in curriculum 2013 is done integratedly to give a chance to students to develop their thinking ability, process skill, and scientific attitude. The meaning of integration in science learning is the existence of a relation between some aspects and material presented on the basic competence of science, so it creates one or some themes based context in learning. Context based learning could improve soft skill and give a positive influence towards student's value which includes in valuing affective (Rosana, et al., 2014).

The development of integrated learning

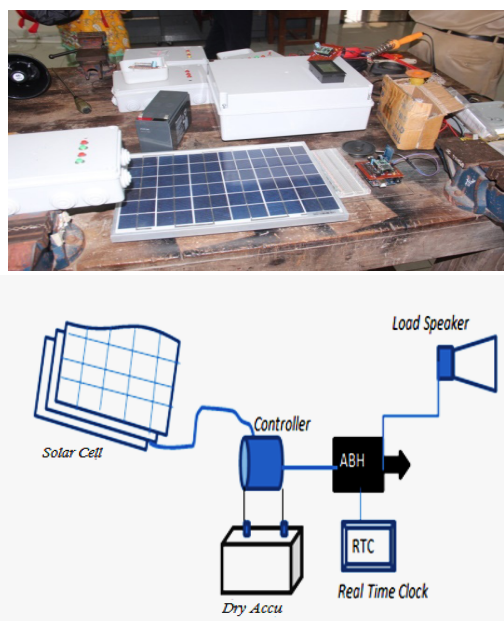
could take one topic of certain fields; then it is completed, discussed, expanded and deeply explained with other fields. The theme could be developed from the issue, happening, and problem. What is developed in this study is the application of Audio Bio Harmonic System (ABHS) with solar energy to improve crop productivity. Giving sound wave with frequency 3000 – 6000 hertz to some plants could stimulate stomata to open (Yulianto, 2008).

The integration in science learning is supposed to make the learning process more meaningful, effective, and efficient. Students could take advantages by knowing concepts and show their ability to connect those concepts to daily life (Wijayanti & Basyar, 2016). The integrati-

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on could also improve scientific literacy so students could know and realize social needs so that they could participate in the economy-oriented economy (Sofowora & Adekomi, 2012). Science, technology, and society are learning reformation to provide social needs related to technology.

The condition of technology applied in STS learning process could be seen in the figure below:



**Figure 1.** The use of solar energy to apply ABHS by using natural animal sounds.

This study more pointed to the program evaluation of STM which was done at Science education program, Yogyakarta State University through the application of evaluation model CIPP (context, input, process, and product). The basis for choosing this model saw learning concept where the quality of learning process in STS (Sains Technology and Society) was at least influenced by input, process, and product (Issac & William., 1981). The evaluation of this Stufflebeam model is suggested to be systematical framework as the reference of conception, design, implementation, and assessment of community service program, and give feedback and the assessment of project effectivity to continous improvement (Zhang et al., 2011).

Implementing research and applying ABHS to improve crop productivity are in the concept of CIPP combined with Provus, so it becomes modification. Many types of research evaluating learning process at STM has not been conducted variously and implemented in the community service program directly through

field activity by involving students of science education program. This CIPP model uses some methods, which have been tested in many contexts, developed and strengthened from time to time, and supported by theoretical nad phragmatic literature (Stufflebeam, 1971).

STS learning process has a better influence towards students of SHS in understanding nature of science and their attitude towards science than students taught by the same teacher using a traditionally oriented textbook (Akcaay & Akcaay, 2015). Students using STS approach performed better in understanding the scientific process, their ability to apply scientific concepts related to science and technology, more possitive attitude, and their creativity (bakar et al., 2016). Science learning should always refer to nature of science taught through three aspects; product process, and attitude (Prabowo, 2015).

Evaluation problem towards STS program which is integrated with community service program in improving crop productivity is quite complex because it affects directly to farmers empowerment. Rationally, Stufflebeam & Shinkfield referred to Tyler opinion who said that: "evaluation should determine the congruence between performance and objectives" (Stufflebeam & Shinkfield, 1985). The evaluation has to result in the same opinion between work and real condition, it could not be manipulated, and it should avoid subjectivity. Learning program should be evaluated to know the weaknesses and deficiency in the process of STS learning espesially what is related directly to farmer' need. Reviewed from the perspective of STS program continousity, relevant knowledge that could be inserted in the program should be guided by social opinion and responsibility. This case, in its turn, needs new type which is appropriate to STS education targetted and done on purpose so that it is oriented to literacy (Zoller, 2012).

This research has benefit to building a new instrument model to evaluate STS learning program in improving crop productivity through applying Audio Bio Harmonic System (ABHS) with solar energy through the program of modified evaluation model between CIPP model and Provus which is called evaluation model "Coni P2". This research is also used to evaluate a program designed in the form of community service program to give help to STS staffs in science education program Faculty of Science and Mathematics in determining whether this program should be stopped, continued, or repaired. Worthen & Sanders explained that: "evaluation is the process of delineating, obtaining, and providing



useful information for judging decision alternatives" (Worthen & Sanders, 1981).

## METHODS

This research is an evaluative research (Suharsimi & Jabar, 2010) because it was oriented to the analysis based on program evaluation approach focusing on organizing the program, it was a view showing procedure and process of the program. The component of evaluation model used was Stufflebeam evaluation model (CIPP). The steps used were Malcolm Povus'. The techniques of collecting data were Delphi, FGD, questionnaire, observation, interview and documentation study. Besides, the writer also analyzed program preparation by analyzing variables in CIPP model that was confirmed with a target which was the measurement of program readiness. This research involved four variables; they were context, input, process, and product (Daryanto, 2008).

The population in this research was 37 students taking biophysics class and 25 farmers incorporating with two groups in Pengasih sub-district, Kulon Progo regency, Yogyakarta; they were Tani Ngudi Makmur group and Tani Ngudi Luhur group in Kedungsari village. Taking sample was done by using non-probability sampling in the forms of purposive sampling and quota sampling. The amount of sample was 3 farmers (chili farmer, onion farmer, and long bean farmer). The data were gathered by using a questionnaire to know students' and farmers' opinion extensively. The instrument in this research consisted of four components; they were context variable, input, process, and product, which consisted of some questions related to STS program in applying ABHS to improve crop productivity.

The data taken from observation and interview towards farmers and students were then analyzed by organizing them into categories, explaining into some units, done syntetically, and arranged in patterns to ease the interpretation. The data were divided into two, qualitative and quantitative. Quantitative data were analyzed by Exploratory Factor Analysis (EFA) with the help of SPSS 20.0 application. The latent variable was formed based on theoretical concept with some

indicators/manifests (Gozhali, 2008). The purpose of using EFA was to test whether the formed construct could be explained its indicators or not. If the indicators could explain the available construct or variable, the validity would be showed in high loading factor value. Each item in the content should be higher than 0,3 ( $>0,3$ ), as the opposite, if the item was lower than 0,3 ( $<0,3$ ), it was considered as not valid, it should be thrown or deleted, Nurosis (1086). The construct was tested by seeing the value of Kaiser Mayer Olkin (KMO) which was expected to be higher than 0,5 ( $>0,5$ ). The analysis with EFA to test the validity was done in the second test and construct normality test before being analyzed with CFA in the third test. The reliability of data measurement was seen from its alpha value. If the alpha value was  $>0,7$ , the instrument was reliable, and if it was  $<0,7$ , it was not reliable.

Test by using Cronbach Alpha was used to know instrument reliability in the trial test. The result was analyzed by using CFA model to know the validity of each instrument; they were context, input, process, and product. Validity analysis by using CFA could be seen from t-value, and content factor could be seen from alpha value. If the alpha value was  $>0,03$  (significantly 5%) compared to table t-value 1,96, the item could be said valid. If the alpha value was written in red, the item could be said invalid so it should be changed or not be used.

Appropriateness test model could be seen from RMSEA which had to be lower than 0,8 and Goodness of Fit Index (GFI) which had to be higher than 0,90, Wijanto, 2008). Test appropriateness between theoretical and empirical models was based on four categories; (1) Chi-square, (2) Significant Probability, (3) Root Mean Square of Error Approximation (RMSEA), and Goodness of Fit Index (GFI), the standards used could be seen in Table 1.

The method of applying ABHS technology as a focus of STS program was described with its indicators in the following draft.

Whereas the methods of applying STS in ABHS activity to improve crop productivity were done as what Table 2 showed.

**Table 1.** Goodness of Fit Index

Index	Cut of value	explanation
Chi-Square (X <sup>2</sup> )	small	The smaller X <sup>2</sup> , the better
Probability (p)	$\geq 0,05$	Should be higher than 0,05
RMSE	$\leq 0,08$	Average difference
Goodness of Fit Index (GFI)	$\geq 0,90$	The value approximately 0-1



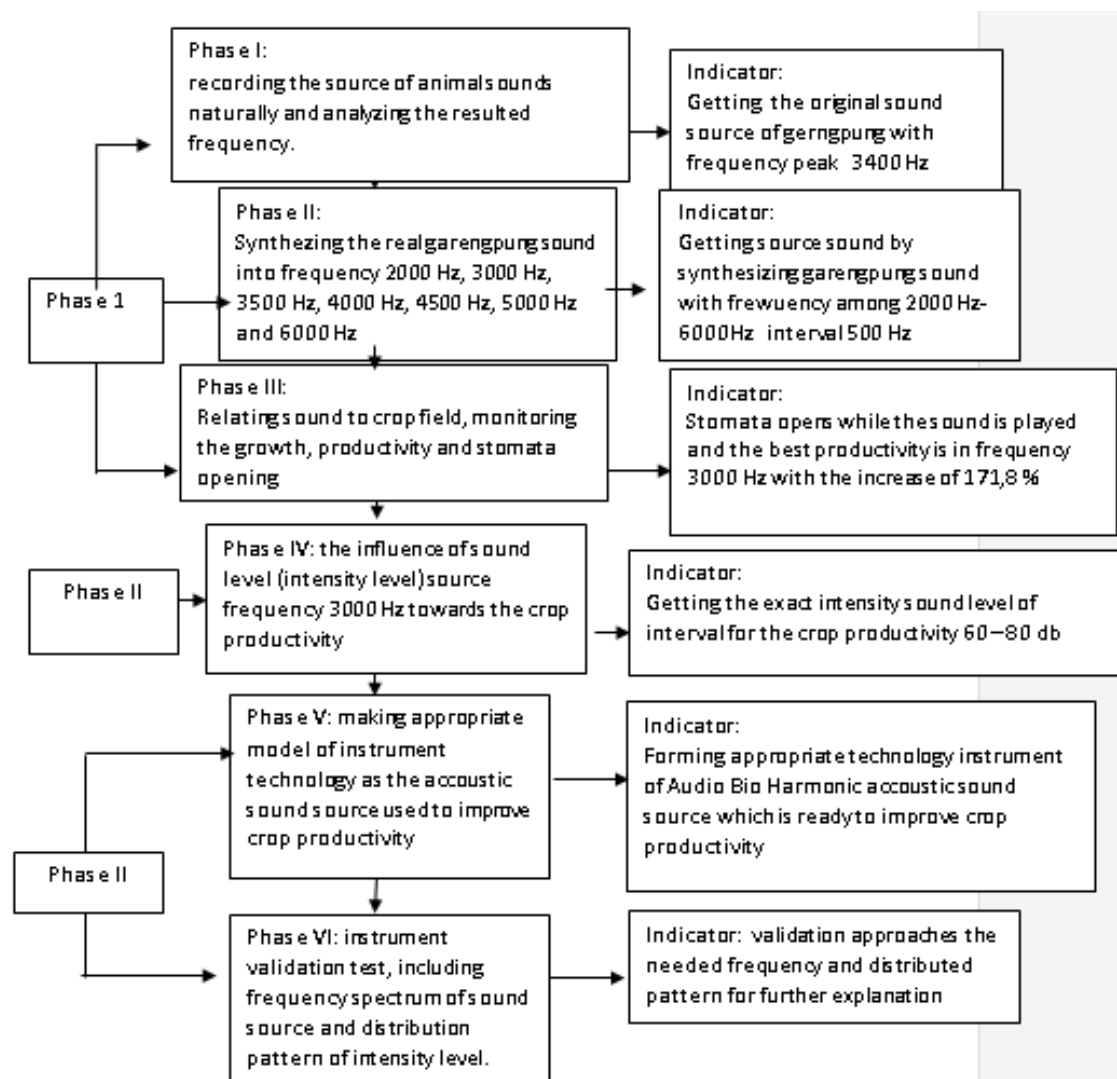


Figure 2. Steps of applying ABHS technology

## RESULTS AND DISCUSSION

Model of CIPP evaluation in STS learning program was developed in order to be used to evaluate the application of ABHS in improving crop productivity. The previous research result showed that learning in local society environment, like the case of National Baluran Park, could improve students learning achievement including creative thinking skill (Putra & Iqbal, 2016).

Steps description of developing evaluation model could be systematically and practically used by a lecturer to evaluate the program integrated with the community service program. The development was begun with theoretical study, first observation or need analysis, and empirical findings on the field so that the first draft of evaluation model development could be designed. The first draft was then criticized by some experts th-

rough Delphi technique consisting of researcher team or community service program team and other lecturers who were considered as experts in evaluation field. The result of Delphi made components from the first draft change in many ways especially in the content of evaluation context, composition, instrument amount, STS evaluation program component, the format of writing instruction in instrument column, and linguistic construction problem.

When validating the content of first STS evaluation model program in applying ABHS by researchers and evaluation experts, Focus Group Discussion (FGD) was done at the same time. The result of FGD was determining evaluation standard in STS applying ABHS which consisted of program context, program input, program process, and program product. The agreement result of FGD became the standard to evaluate STS

**Table 2.** Model syntax of STS learning to apply ABHS

Phases of STS learning	Teaching activity/field activity
Phase 1 (Invitation) <ul style="list-style-type: none"> <li>• Digging issue or problem by students</li> <li>• Connecting new learning with the previous learning</li> <li>• Identifying issue or problem in society which is related to the discussed topic</li> </ul>	<ul style="list-style-type: none"> <li>• Lecturer asks some effective questions so that the students are motivated to learn biophysics applying ABHS to improve crop productivity</li> <li>• The lecturer gives a positive response to the students trying to answer</li> <li>• The lecturer explains main material and practical benefit that will be got</li> <li>• The lecturer divides students into some groups</li> <li>• The lecturer guides students doing experiment about applying ABHS together with Tani Ngudi Luhur and Tani Ngudi Makmur groups to explain and solve the problem, then report the observation result to be concluded</li> </ul>
Phase 2 (Exploration) <ul style="list-style-type: none"> <li>• Designing and doing experiment or test to collect data</li> <li>• Training science process skill</li> <li>• Sharpening scientific work and scientific attitude</li> <li>• Discussing in group to take the conclusion</li> </ul>	<ul style="list-style-type: none"> <li>• The lecturer directly invites students to discuss the result then it is applied in other situation</li> <li>• The lecturer pays attention to the result of all activities done by groups</li> <li>• The lecturer re-observes students' activities if there is a group giving unclear conclusion</li> </ul>
Phase 3 (proposing explanation and solution) <ul style="list-style-type: none"> <li>• Students build the concept by themselves</li> <li>• Students discuss</li> <li>• Solution to the problem faced by society</li> </ul>	<ul style="list-style-type: none"> <li>• The lecturer gives summary or brief explanation about the right concepts among students</li> <li>• The lecturer asks a question which is conceptual.</li> </ul>
Phase 4 feedback <ul style="list-style-type: none"> <li>• Explaining the phenomena of productivity improvement naturally with animal sound stimulant based on the organized concept</li> <li>• Explaining some application to give meaning</li> <li>• Concept understanding reflection</li> </ul>	

(Modified from Yager, 1992)

program in applying ABHS in three farming fields which were tested.

The practice of evaluating STS program in applying ABHS exactly used the model following component standards decided by evaluation standard from FGD result. This evaluation model component had been tested many times and repaired so that it became the appropriate model to be used for STS program in applying ABHS. The technique used to analyze the data was descriptive analysis by using the average score and total average score to be then confirmed with conversion standard by using criteria that had been agreed.

The result of context evaluation of STS program applying ABHS consisting of the description of crop commodity kind and field which was appropriate with program context, program need, and a chance for students to do this program had been "very good". Input evaluation consisting of field quality, seed quality, and

ABHS equipment, was evaluated by farmers and students, had a "very good" category because the practice of input was very selective whether in preparing ABHS media with solar energy, training students, and training farmers to support the success of STS in applying ABHS with solar energy. The result of process evaluation in STS program applying ABHS was "very good." Students had done very maximally, farmers worked professionally, when applying ABHS with solar energy the farmers also did independently.

The result of process evaluation from observation during students training had 0,69 value of "reliability" which was "good" and the observation result during farmers training was 0,72 value of "reliability" which was also "good." Observation process was started with looking at students presentation and discussion about concept and technique in applying ABHS to improve crop productivity. Observation process was also done by looking at farmers during practice and discus-

sion about technique to apply ABHS to improve crop productivity.

The observation result showed that STS learning media which was ABHS with solar energy, had been used very well and maximal, wither by students (0,86) or farmers (0,89). Students motivation (0,89) and farmers motivation (0,88) in training activity of applying ABHS to improve crop productivity had high ebthusiastic, it was seen from the result of assessment evaluation which was considered as “very good” category. ABHS was applied during photosynthesis, because it had a big role in photosynthesis, carbohydrate transportation, forming protein, balancing ion, regulating plant stomata and activating plant enzim water use and another process (El-Sawy et al., 2008; El-Tantawy, 2009).

The motivation in training to apply ABHS as a plant growth stimulant and crop productivity evenly came form training participants themselves, it was completed with documentation data about the success of applying ABHS in some locations that were tested. The technique of applying ABHS in some kind of plants (corn, chili, and onion) was good enough. Applying ABHS caused the plants optimally consume nutrition through the air which had many substances needed by plants. The highest result was got in an-organic since there were many nutrients during fertilizing leaves. The lowest result was caused by the lack of nitrogen which caused the lack of productivity (Shangguan et al., 2000, Lawlor, 2002). To keep the quality of ABHS implementation in farmers, they were guided continously by students. The guidance also became instrument data.

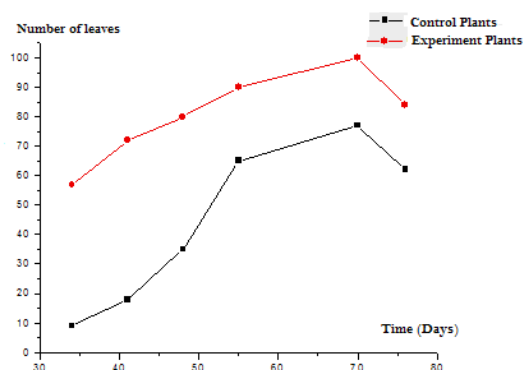


Figure 3. Chart of leaf growth (every 10 days)

Product evaluation in this research focused on two aspects, first was students' improment skill and farmers in using ABHS, and second was crop productivity; (1) chile reached to 76,4%, (2)

onion reached to 56,3%, and (3) corn reached to 67,8%. Besides, the influenmce of implementing ABHS towards plant growht was inspected as it was seen in the following chart, which compared plabtgrowth given ABHS treatment (experiment group) and not given (control group).

From the chart, there was a better significant growth from experiment plant given treatment by ABHS technology of solar energy than farmers competence in applying ABHS with solar energy; all were indicators arranged from the result of developed evaluation model.

The developed evaluation model had been tested empirically, and it fulfilled Goodness Fit Index criteria using Confirmatory Factor Analysis (CFA). The instrument of result development had validity > 0,3 and reliability >0,70. So, the instrument of developed evaluation model could be used to evaluate STS program i applying ABHS in farming fields belonging to Tani Ngudi Makmur and Tani Ngusi Luhur groups at Kedungsari village, Pengasih subdistrict. Evaluation component and STS indicators in applying ABHS with solar energy had successfully been organized in systematic. The model used to evaluate STS program in applityng ABHS with solar energy was CIPP model. This model evaluated STS in applying ABHS with solar energy by using components from CIPP which were context, input, process, and product. The analysis result of components and indicators of evaluating STS program in applying ABHS with solar energy was tested empirically to get valid and reliable criteria for instrument constructs and test model which was hypothesized by using the test result in the field.

## CONCLUSION

The result of this research was the success of STS approach done at science education program, Yogyakarta State University, which had been evaluated through CIPP model (Context, Input, Process, and Product). This model was chosen because the quality of learning result through STS approach (Science Technology and Society) was influenced by input, process, and product. The process assessment result from observation during students' training had 0,69 value “good reliability” and during farmers' training had 0,72 value “good reliability.” The process of observation was started with seeing students presentation and discussion about the concept and technique of implementing ABHS to improve crop productivity. Observation process was

also done by seeing farmers during the practice and discussion of the technique of implementing ABHS to improve crop productivity.

The result of CIPP evaluation in this research had two aspects, first was improving students' skill and farmers' skill in using ABHS, and second was crop productivity; (1) chili reached 76,4%. (2) red onion increased to 56,3%, and (3) corn increased to 67,8%. There was significant influence from applying ABHS towards plant growth. The outcome of this research was integrated science learning material with STS approach and appropriate technology of ABHS with solar energy.

The result of this research is highly recommended by lecturer and science teacher to improve learning based research like applying ABHS with STS approach, so there is an integration between physics and biology concepts. STS approach is suggested because society really needs scientist contribution in science in solving a problem related to using technology in the field in many life activities.

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## USABILITY TESTING ANALYSIS ON THE BANA GAME AS EDUCATION GAME DESIGN REFERENCES ON JUNIOR HIGH SCHOOL

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### ABSTRACT

Learning media is one of the important elements in the learning process. Technological development support makes learning media more varied. The approach of using digital technology as a learning media has a better and more effective impact than other approaches. In order to increase the students' learning interest, it requires the support of an interesting learning media. The use of gaming applications as learning media can improve learning outcomes. The benefits of using the maximum application cannot be separated from the determination of application design. The Bana game aims to increase the ability of critical thinking of the junior high school students. The usability-testing analysis on the Bana game application is used in order to get the design reference as an educational game development. The game is used as an object of the analysis because it has the same characteristics and goals with the game application to be developed. Usability Testing is a method used to measure the ease of use of an application by users. The Usability Testing consists of learnability, efficiency, memorability, errors, and satisfaction. The results of the analysis obtained will be used as a reference for educational game applications that will be developed.

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**Keywords:** learning media; education games; usability testing; design reference

### INTRODUCTION

Various efforts were made to improve students' abilities. Research conducted by (Lestari, Widiyatmoko, Alimah, & Juliyani, 2015) showed that the use scenario of the game in a learning process could increase the ability of the participants. Digital technology offers many opportunities to create a compelling content (Tabor, 2013). The approach of using digital media technology as a learning media has better and more effective impacts than other approaches (Reeves, 1998). According to (Lee, 2015) in terms of social interaction and collaboration, the use of digital media (iPad & games) conducted in the learning center can increase the frequency of

interaction of children, either with colleagues or with teachers.

It happens because when they get a new experience (either in the form of a difficulty or a solution), they tend to communicate with both the teachers and their colleagues. (Rutten, Van Joolingen, & Van Der Veen, 2012) also stated that the use of digital media (computer simulations) could improve the students' ability, especially for laboratory work materials. In addition, there is a learning motivation development in children because the use of digital media is interesting and fun (Lee, 2015). (Kocadere & Çağlar, 2015) also stated that students felt more enjoyed and motivated in learning when using digital media (video games). Digital media are also effectively able to help to practice some of the important learning theories developed (Pischetola & Cattolica,

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2011).

The game is a broad concept that refers to all game structures consisting of rules, goals, and challenges made for diversion or entertainment (Cheng, Chen, Chu, & Chen, 2015). Until now, the game has developed variedly; video games are one type of game variation that has grown rapidly. Currently, most people are encouraged to use the game as a means of play and entertainment (Felicia & Jabbar, 2016). A survey is conducted of more than 4,000 American households about the use of video games. From the survey results are obtained the data of age distribution of video game users, 27% under the age of 18 years, 29% between 18-35 years old, 18% between age 36-49% and 26% 50 years and above. The reason why the users like video games so much are 'enjoying' (Imbellone, Botte, & Medaglia, 2015). According to (De Aguilera & Mendiz, 2003) the benefits of using video games in learning activities are undoubtable. In terms of generating motivation, video games are very useful for users to practice skills, are also able to improve perceptions and stimulation and able to develop the ability of users in solving problems. In addition, video games are also able to develop the ability assessment of a strategy, organizing media and tools to get answers / intelligent solutions. (Dondlinger & Dondlinger, 2007) also stated that video games could have a positive effect on the learning process, although there is widespread consensus that games only motivate users to master their game skills.

The Bana game application is one of the serious game developed with the background of Baluran National Park with the aim to improve the ability of critical thinking of junior high school students (Men & Iqbal, 2016). This game is developed to make students feel happy and feel the competition in solving the existing problems. This game genre is adventure genre; competition factor in this game is able to provide motivation for students to learn. The use of game background using real-world conditions can also have an impact on increasing motivation for players (Kahn et al., 2015). This game consists of several levels. Each level has its own difficulty level. The Difficulties at each of these levels can trigger students to resolve the challenge. (Giammarco, Schneider, Carswell, & Knipe, 2015) stated that the game players basically have a spirit and passion for finishing every level of the game and advancing to the next level.

The age of students when entering the junior high school level in Indonesia ranges between the ages of 12-14 years. (Eccles, 1999)

states that in children aged 6-14 years (middle-aged and early adolescents) is a developmental period for children to build their identity. At this time, children prepare to move toward adults by being competent, independent and trying to get involved with the world outside of their families. The change also occurs on the biological and cognitive side of children. The proper learning methods will greatly help the learning process of children. (Rohwati, 2012) stated in a study conducted in SMP Negeri 1 Wonosobo that used Education Game was proven to improve learning outcomes and the activities of the students. Putra (2016) stated that Serious Games Inspired By Baluran National Park is able to Improve Students' Critical Thinking Ability. (Girard, Ecalle, and Magnan, 2013) also stated that the use of Serious Game in the learning process is very helpful. The use of Serious Game and Education Game associated with the design of Entertainment Games, making it more attractive (Arnab et al., 2015).

The availability of gaming applications as an interesting, easy-to-use, and useful learning media is essential to improve the students learning outcomes. The Interface of an application has a crucial role to the user. An app interface is a meeting point between users and apps. A good interface can represent the functionality of an application and make it easier for app users. To develop game applications that have a good interface, the required information needs the right interface. In order to develop easy-to-use applications, it has to meet the needs of users and able to provide benefits as expected. This study will be conducted using the test analysis using Usability Testing in gaming applications The Bana. This game is chosen as the object of analysis because it has the same characteristics and functions similar to the game application to be developed, namely as a learning media in junior high school students. The Usability Testing is an analysis of an application interface testing (Nielsen, 2012). The Usability Testing consisted of learnability, efficiency, memorability, errors, and satisfaction. The analysis results may become the source of interface reference design gaming applications that will be developed further. (Denton & Coysh, 2011) and (Sonstebly & DeJonghe, 2013) also run the same scenario to get references to further system development.

## METHODS

Usability Testing method is the method used to measure the ease of use of an application

by the user. This method is very suitable for measuring the usability of an application or information system. In this study, the application will be used as a measurement object, which an educational game is called The Bana. The Bana is an educational game app for junior high school students to teach about the environment and nature conservation by locations setting in the Baluran forest located in Baluran National Park, Situbondo.

This research was conducted at SMPN 1 Asembagus of Situbondo Regency. The technique of sample selecting that will be the research respondent is using Non-Probability Sampling method. The numbers of respondents involved in this study were 90 students divided into 3 groups of users: the non-expert users, active users, and skilled users. The non-expert users are students who have never been entirely using The Bana game; the active users are students who often use The Bana game; whereas the skilled users are more advanced students (able to complete all of the levels) in The Bana game.

Data collection methods have an important role in the success of a study. In this study, data collection method used is by using questionnaire. The scale used is Likert scale (Beglar & Nemoto, 2014) with range 1 to 5 with details as follows:

1. The SA Answer (Strongly Agree) is rated 5
2. The A Answer (Agree) is rated 4
3. The N Answer (Neutral) is rated 3
4. The D Answer (Disagree) is rated 2
5. The SD Answer (Strongly Disagree) is rated 1

The usability criteria used to refer to (Nielsen, 2012) with the five following components:

- Learnability: measuring the level of users' convenience to fulfill the basic tasks when the users see/use the application for the first time
- Efficiency: measuring the level of speed in doing a particular task after studying the application
- Memorability: measuring the incidence of users' convenience in reusing the application after not using it for some time
- Errors: measuring the error performed by users, and how to fix or deal with it
- Satisfaction: measuring the level of user satisfaction in using the application

### Game Experiment Scenarios

The experimental process of using the game application performed by students consists of several levels:

1. The ability to open the game app

2. The ability to comprehend the function of each menu on the home page of the game application
3. The ability to choose the game level
4. The ability to understand the game instruction
5. The ability to complete the game at the 1<sup>st</sup> level
6. The ability to complete the game at the 2<sup>nd</sup> level
7. The ability to complete the at 3<sup>rd</sup> level
8. The ability to complete the game at the 4<sup>th</sup> level
9. The ability to understand the function on the menu that appears when the game is finished
10. The ability to end the game and close the game app

After the data collection, it is conducted the data processing with the following stages:

1. Validity Test and Reliability to test the instrument (questionnaire) used
2. Descriptive analysis to determine the level of usability of The Bana
3. Grouping results of a calculation to measure The Bana application usability referring to Table 1.

**Table 1.** Grouping Category

Score	Qualification
4.01 – 5,00	Very good
3.01 – 4.00	Good
2.01 – 3,00	Enough
1.01 – 2.00	Less good
0.01 – 1.00	Very Less Good

## RESULTS AND DISCUSSION

Before the respondents fill out the questionnaire, the respondents run The Bana in accordance with a predetermined scenario. It is hoped that each respondent gets the same user experience before filling out the questionnaire. Therefore, the results of the questionnaire are more focused.

The questionnaire used is divided into five groups of questions according to the criteria of usability as in Table 2.

The respondents of this study are 90 students divided into three groups of users: the non-expert users, active users, and skilled users. There are 30 people of the seventh grade students representing the non-expert users. It is because the seventh grade students still lay with the applications already in use long Bana in SMPN 1 Asembagus. Active users represented by 30 people of the



**Table 2.** Questionnaire Group

Variable	Item Question	Type	Function
Learnability	P1 - P6	Numerical	measuring the level of users' convenience to fulfill the basic tasks when the users see/use the application for the first time
Efficiency	P7 - P9	Numerical	measuring the level of speed in doing a particular task after studying the application
Memorability	P10 - P13	Numerical	measuring the incidence of users' convenience in reusing the application after not using it for some time
Error	P14 - P16	Numerical	measuring the error performed by users, and how to fix or deal with it
Satisfaction	P17 - P19	Numerical	measuring the level of user satisfaction in using the application

eighth grade students; it is because they have frequently used The Bana applications. Skilled users represented by 30 people of the seventh grade students; it is because they often use and have skills in completing The Bana application. Respondent profile classification is presented in Table 3.

**Table 3.** Respondent Profile Classification

User Category	Amount	Class
Non-expert Users	30 students	Seventh Grade Students
Active Users	30 students	Eighth Grade Students
Skilled User	30 students	Ninth Grade Students

**Validity and Reliability Test**

The first stage of data analysis is the validity and reliability test of the instruments used. The validity test is done to see whether the instrument (questionnaire) used is valid or not. The validity test performed was using Pearson Correlation with 0.05% significance level using SPSS. In order to analyze Pearson Correlation test results, the researcher first determines the r value of the table. The R value is obtained from r table with degrees of freedom (df) = n-2 where n is the number of respondents, so the df is 88. From the r table, its value is 0.2072. Then, the r table value is compared to the r value of Pearson Correlation test of all indicator (question item) on the instrument. An indicator or item of the question is said to be valid if the value of r count > r table. The validity test results are presented in Table 4.

Based on the validity test results conducted all indicator/item questions on the instrument, it has met the validity test criteria so that it is declared as valid.

**Table 4.** Validity Test Results

Variable	Indicator / Item	R count	R table	Results
Learnability (LN)	LN1	0.755	0.2072	Valid
	LN2	0.744	0.2072	Valid
	LN3	0.719	0.2072	Valid
	LN4	0.752	0.2072	Valid
	LN5	0.659	0.2072	Valid
	LN6	0.620	0.2072	Valid
Efficiency (EF)	EF1	0.906	0.2072	Valid
	EF2	0.908	0.2072	Valid
	EF3	0.921	0.2072	Valid
Error (ER)	ER1	0.733	0.2072	Valid
	ER2	0.751	0.2072	Valid
	ER3	0.767	0.2072	Valid
	ER4	0.734	0.2072	Valid
Memorability (MEM)	MEM1	0.912	0.2072	Valid
	MEM2	0.910	0.2072	Valid
	MEM3	0.874	0.2072	Valid
Satisfaction (SAT)	SAT1	0.835	0.2072	Valid
	SAT2	0.720	0.2072	Valid
	SAT3	0.783	0.2072	Valid

The next is the reliability test using Cronbach Alpha. An instrument is said to be reliable if the Cronbach Alpha value of the variable is greater than 0.60. Table 5 is the result of the reliability test of the instrument.

Based on the results of validity and reliability test, it can be concluded that all question items on the instrument used to measure The Bana application usability have fulfilled the criteria of validity and reliability test that can be said

to be valid and reliable.

**Table 5.** Reliability Test Results

Variable	Cronbach's Alpha	Results
Learnability (LN)	0.792	Reliable
Efficiency (EF)	0.899	Reliable
Error (ER)	0.721	Reliable
Memorability (MEM)	0.880	Reliable
Satisfaction (SAT)	0.704	Reliable

### Descriptive Analysis of Usability Testing

This study will observe whether the usability level of The Bana application meets the usability criteria according to Jacob Nielsen. At this stage, the researcher analyzed 4 (four) data groups representing the respondent group such as:

1. All respondents are 90 students consisting of 30 non-expert users, 30 active users, and 30 skilled users
2. The non-expert users are 30 students
3. The active users are 30 students
4. The skilled users are 30 students

The average calculation result of all criteria in the four groups of respondents is presented in Table 6-9.

**Table 6.** The average calculation results of each criterion on all respondents

Criteria	Sample Number	Average	Median
Learnability	90	3.84	3.67
Efficiency	90	3.94	4
Error	90	3.89	3.75
Memorability	90	3.87	4
Satisfaction	90	3.7	3.67

**Table 7.** The average calculation results of each criterion on the non-expert users

Criteria	Sample Number	Average	Median
Learnability	30	3.53	3.5
Efficiency	30	3.48	3.33
Error	30	3.47	3.5
Memorability	30	3.48	3.33
Satisfaction	30	3.53	3.67

Based on the results of the calculations in Table 6-9, it appears that the level of usability

of The Bana application across all user groups, as well as the non-expert, active, and skilled users. Based on Table 6 with the total respondents of 90 people, it shows that the Bana application has a good level of usability with Learnability criterion value (3.84), Efficiency (3.94), Error (3.89), Memorability (3.87), and Satisfaction (3.7). This indicates that the average value of each criterion based on the perception of all users is a good category range (3.1 – 4.0).

**Table 8.** The average calculation results of each criterion on the active users

Criteria	Sample Number	Average	Median
Learnability	30	4.00	4
Efficiency	30	3.94	4
Error	30	4.02	4
Memorability	30	4.00	4
Satisfaction	30	4.02	4

**Table 9.** The average calculation results of each criterion on the skilled users

Criteria	Sample Number	Average	Median
Learnability	30	4.28	4.33
Efficiency	30	4.4	4.33
Error	30	4.34	4.5
Memorability	30	4.43	4.67
Satisfaction	30	4.35	4.33

According to the Table 7, the non-expert users who first-time use the Bana application were 30 people indicating that the Bana application has a good level of usability with Learnability criterion value (3.53), Efficiency (3.48), Error (3.47), Memorability (3.48), and Satisfaction (3.53). This indicates that the average value of each criterion based on the perception of a non-expert user is in a category range (3.1 – 4.0). These results indicate that the Bana application is easy to understand, easy to remember and easy to use by non-expert users who first time use it.

According to the Table 8, the active users that have been frequently used the Bana application are 30 people indicating that the Bana application has a good level of usability with Learnability criterion value (4.00), Efficiency (3.94), Error (4.02), Memorability (4.00), and Satisfaction (4.02). This indicates that the average value of 3 (three) criteria is in a good category range (Learnability, Efficiency, Memorability) and 2 (two) criteria are in the very good category range

**Table 10.** Result of All Respondents Capability Grouping

Users	Usability Testing Criteria (In Category)				
	Learnability	Efficiency	Error	Memorability	Satisfaction
All Users	Good	Good	Good	Good	Good
Non-expert	Good	Good	Good	Good	Good
Active	Good	Good	Very good	Good	Very good
Skilled	Very good	Very good	Very good	Very good	Very good

(Error and Satisfaction). These results illustrate that the Bana application has a good quality and tend to be very good based on votes of the active users who have often used the Bana.

Based on Table 9, the skilled users who are frequently and skillfully in the use of the Bana application are 30 people indicating that the Bana application has a good level of usability with Learnability criterion value (4.28), Efficiency (4.4), Error (4.34), Memorability (4.43), and Satisfaction (4.35). This indicates that the average criteria are in a very good category range. These results illustrate that the Bana application has a very good quality. The frequency of use and ability of skilled users affect the assessment of the application usability of the Bana as shown in Table 10.

## CONCLUSIONS

From the results, it is inferred that the use of the Bana application by junior high school students can be very well received. It can be seen in the results of grouping capabilities in table 10. The non-expert users, as the first time users, did not experience such a constraint with the result as a good category. Based on the result of grouping ability of all respondents in table 10 also can be seen that the ability of the skilled users is in a very good category. It shows that the frequency of use in the Bana application is able to improve the mastery of gaming of its users. From these results, it can be concluded broadly that design interfaces in the Bana applications are good and easy to use category.

It is recommended that the Bana application can be used as a design reference for the further development of education game application. This reference will be valuably important because the development of an application will be able to meet the expected needs. However, the condition of respondents who will be the object of research should be well observed since the technological developments that occur in urban and rural areas are different. This will indirectly affect the habits and behavior of people (includ-

ing children) as it to enable different designs to solve this problem.

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## THE EFFECT OF SCIENCE LEARNING INTEGRATED WITH LOCAL POTENTIAL OF WOOD CARVING AND POTTERY TOWARDS THE JUNIOR HIGH SCHOOL STUDENTS' CRITICAL THINKING SKILLS

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### ABSTRACT

This study aims to analyze the influence of science learning integrated with the local potential of wood carving and pottery to the critical thinking skill of class VIII SMP students. This research is a quasi-experimental research (quasi-experiment). The research design uses pretest-posttest control group design. The population in this study is the students of class VIII MTs Negeri Piyungan, while the sample is the students of class VIII A and VIII B MTs Negeri Piyungan. The technique of collecting data in this research is in the form of test. The data collection instrument is a critical thinking skill descriptive test. The data were analyzed using ANOVA test. The results of this study indicate that the learning of science integrated with the local potency of wood carving and pottery have an effect on critical thinking skill of class VIII SMP student. This effect is indicated by a significance of 0.008 (significance <0.05).

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**Keywords:** science learning; local potential; critical thinking skill

### INTRODUCTION

Indonesia is a country rich in potentials, cultures and natural resources in each region. The potentials of the region in Indonesia is abundant, including the local potential associated with the entrepreneurial world (home industry).

Based on Law no. 20 of 2003 on National Education System (Sisdiknas), it provided an excellent opportunity for teachers as implementers of learning to raise potential local issues into learning. Implementing the integration of local potential into learning is still experiencing difficulties, when the teacher did not understand how to properly integrate the potential of the environment (especially local culture) into the learning process (Alexon, 2010); and the absence of a mo-

del of learning that can be adapted by integrating local potential (Suratsih, 2010). Suratsih (2010) disclosed several factors that prevent teachers from utilizing local potentials in learning, which are the huge burden of teaching, lack of adaptable models, facilities, funding and times.

Looking at the current educational developments, teachers should not only provide conventional teaching (teacher center) that is only using lectures and memorization. Students' learning habits with memorization without much thinking made the students overwhelmed when faced with problems that require a further solution; this is seen when students do the descriptive tests. Sometimes the answer did not match the question. So it is with other problems that required reasoning (Asfiah, 2013).

The science subjects in the 2013 curriculum were highly relevant to be integrated with the local contents. However, in reality, science

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learning has not been linked to the local potential around students. Given the importance of this lesson, teachers were expected to choose appropriate methods and approaches in optimizing students involvement in enhancing meaningful learning processes (Syafii and Yasin, 2013). According to Holbrook (2005) in Sha'ban & Insih (2016), he assumed that science learning is irrelevant in the view of students and will be disliked because the emphasis of understanding basic concepts and the basic understanding of science is not associated with matters relating to the environment of students daily life. If it is associated with the environment of everyday life, it will be liked by students so as to provide a meaningful learning experience in students.

According to Suastra et. al. (2011) stated that the 2013 curriculum required the development of science learning in junior high schools in the concept of integrated science, where one of its characteristics is thematic. The right local potential is chosen as the basis for choosing the theme because it is contextual, interesting, and related to real life. The daily local potential is very useful for the life of students and the wider community. The integration of local potential into learning process provided students with the insight into the local potential and local wisdom values (Wilujeng, 2016). It is consistent with the opinion of Ridlo (2005) which stated that the approach of the Exploration of Surrounding Environment (JAS) is an approach that utilized surrounding environment as a learning object. The JAS approach is a learning approach that utilized the natural environment around the students' life, whether physical, social, technological, or cultural as the object of science learning which phenomenon is learned through scientific work (Marianti & Kartijono, 2005).

To overcome the problems of degradation of young people's respect for the potential of the region and to form students who have a comprehension of the nature of science as a whole can be started by improving the learning process associated with local potential around the students. It is inconsistent with the science learning standards that emphasized on the inquiry activities and doing so that it can help students to gain a deeper understanding of the surrounding environment (Kubicek, 2005).

Local excellence (local potential) is anything that could be a region's characteristic that included the products of the earth, art creations, traditions, cultures, services, natural resources, human resources, or others that are the excellence of a region (Kanzunnudin & Oktavianti, 2014).

The local potential is a resource that resided in a particular region (Hatimah, 2006). The local potential in Kasongan Village, Bantul Regency is the wood carving and pottery. The local potential of wood carving and pottery can be used as a science learning resource. The local potential of wood carving is an industry that required the basic material of woods to be processed into various household furniture products, such as tables, chairs, cabinets, beds, and some wooden souvenirs. The local potential of pottery is an industry that made tools by using raw materials from clay or clay soil.

The local potential of pottery in Kasongan Village, Bantul Regency came from natural resources such as clay. The soil used as the basic material for making pottery is processed through several stages. The stage of making pottery consisted at least of soil taking, soil preparation so that the soil became smooth and fine, the formation of pottery using traditional rotary technique, drying using room temperature, gradually burning heating up to 1200 °C, and finishing when alleviating under conditions still smoldering from the stove while doing staining using a wall paint (Anisa, 2016).

There are several stages of wood processing in the furniture industry, they are the preparation stage: the selection of good wood materials for the basic materials of furniture making; drying stage: wood dried by drying in the sun; the stage of forming the furniture section to be made: the cut / sawed wood formed the pieces of furniture to be made; the first stage of smoothing / sanding: each piece of furniture is smoothed by means of sandpaper; the gluing stage: each piece of furniture is strung together into a raw furniture product; the second smoothing stage: the crude furniture is refined until it is completely smooth and ready to be painted or stained to a mature furniture; and finishing stage: the crude furniture that has been smoothed is painted or plastered into a final furniture product (Anisa, 2016).

The existence of Kasongan Village, Bantul Regency in Yogyakarta that has many local potentials can be utilized and integrated into the process of science learning in all levels of education, including science materials in the curriculum of 2013 class VIII junior high. Strategies for integrating local potentials in learning can be done by modifying learning indicators (Santoso, 2010). The learning of science integrated with local potential is a science learning that utilized the local advantages or potentials in a region as a source of learning. Many learning materials can capitalize on the local potential in the environment around

the school, especially science learning materials. Science should be viewed as a way of thinking for the purpose of understanding nature, as a way of investigating to state the phenomenon, and as a body of science resulted from inquiry (Collete & Chiappetta, 1994). The learning process of science as part of the education system used a scientific and contextual approach to making the knowledge more meaningful. This meaningful learning will be felt when the preparation of learning is done with paid much attention to the needs and involvement of students maximally.

Science learning is expected to foster the character of students to be more appreciative of the cultures and resources around them (Khusniati, 2014). In science learning, it is emphasized in the process of suppression of direct experience to develop the ability so that students can explore and understand the surrounding environment (local potential) scientifically by finding out and do or interact directly. It helped students to gain a deeper experience of the surrounding environment in the form of facts, concepts, principles, natural laws, models, and theories that shape knowledge. This in-depth experience will be gained by engaging in the relevant environmental-related (local potential) science learning (Anisa, 2016).

According to Swarabama, et al. (2013) stated that learning should prioritize on the processes and thinking skills, such as defining and analyzing problems, formulating principles, observing, clarifying and communicating. According to Tawil & Liliyasi (2013) stated that critical thinking is the ability to say things with confidence because critical thinking allowed students to solve problems, evaluate and infer from sources found in phenomena, events, and pieces of information around them every day so that the implementation of critical thinking skills in science learning must conform to the nature of the science lesson material related to natural phenomena and daily events. Critical thinking skills are part of high-order thinking skills (Uswatun & Rohaeti, 2015).

Johson (2009) in Muskitta & Djukri (2016) stated that critical thinking is a clear and directed process used in mental activities, such as problem-solving, decision-making, analyzing assumptions, conducting scientific research and training students to have the ability to argue in an organized manner and can systematically evaluate the value of personal opinions and opinions of others. According to Naomi & Zuhdan (2016), the ability to think critically is a process of thinking ability to produce rational decisions by executing the process of digging, recognizing, and assessing all matters related to being considered in deci-

on making. The process involved the ability to analyze, synthesize, identify and solve problems, conclude and evaluate so that it can be used as a result of students science learning.

Rudd, Baker & Tracy (Cavus & Uzunboylu, 2009) revealed that critical thinking is a reasonable, purposive, and introspective approach to solving problems. According to Quitadamo, et al. (2008) stated that critical thinking skills influenced students' academic and professional success or success in the future. Critical thinking skills are critical to being trained and developed in students so that they can make decisions and solve problems, whether in school, private life, or in the working environment later on. These critical thinkers are expected to be the agents of change and answered to the challenges of the 21st century that can bring this country towards a better future (Syarifah & Sumardi, 2015).

Afrizon, et al. (2012) argued that there are five aspects or categories of critical thinking skills, namely: provide a simple explanation, build core competencies, conclude, provide further explanation, and strategies and tactics. According to Ennis (1991) in Fakhriyah (2014) stated that the characteristics of critical thinking skills, namely: (1) seeking a clear statement of each statement; (2) finding an excuse; (3) trying to know the information properly; (4) using a credible source and mention it; (5) taking into account the overall situation and condition; (6) trying to remain relevant to the main idea; (7) recalling the original and fundamental interests; (8) looking for alternatives; (9) behaving and thinking openly; (10) taking a position when there is sufficient evidence to do something; (11) seeking as much explanation as possible; (12) being systematic and orderly with parts of the whole problem; and (13) being sensitive to the level of knowledge and skills of others.

According to Nuraida (2016), she stated that critical thinking skills are derived from three aspects, namely: interpretation, analysis, and explanation. A total of 11 critical thinking aspects is used as indicators of critical thinking skills in research, which include: linking, interpreting, comparing and differentiating, grouping and classifying, sorting, prioritizing, analyzing, detecting biases, evaluating, making conclusions, and explaining (Hartini & Sukardjo, 2015). The indicator of critical thinking skills according to Uswatun & Rohaeti (2015) is linking, comparing, classifying, analyzing, interpreting, valuing, concluding, and being aware of the environment. Hairida (2016) stated that "aspects of critical thinking skills are giving the simple explanation, building basic

skills, and making the decision.” According to Pratiwi (2016), she stated that “eight indicators from Ennis developed into an instrument of test item includes: (1) defines the term and consider the definition of the appropriate criteria; (2) ask and answer questions that require an explanation; (3) focused questions; (4) to interact with others; (5) inductions; (6) observe and consider the results of observation; (7) show or make assumptions; and (8) to deduce and assess the results of deduction “.

Based on the description above, there are some similarities in the aspect of critical thinking skills, but this study used five aspects of critical thinking skills, namely: providing a simple explanation, connecting skills, comparing and differentiating, analyzing and evaluating, and creating and conveying conclusions.

The purpose of this research is to analyze the influence of science learning integrated on the local potential of wood carving and pottery to the critical thinking skills of students in SMP class VIII.

## METHODS

This type of research is a quasi-experimental research which aims to analyze the influence of two different treatments to the research subject. The research design used is Pretest-Posttest Control Group Design.

This research was conducted in the odd semester of academic year 2016/2017. This study was conducted in MTs Negeri Piyungan.

The subject of this research is the students of class VIII MTs Negeri Piyungan in the academic year of 2016/2017 semester 1. This school is one of the schools that have implemented the 2013 curriculum.

This research was conducted by the quasi-experimental method. The population in this study is all students of class VIII MTs Negeri Piyungan. The sample is determined by cluster random sampling of 6 existing classes; it is obtained that class VIII A is the experimental class and class VIII B is the control class.

Learning in this research is done by using learning tools based on local potential of wood carving and pottery in the form of RPP and assessment instrument based on local potential of wood carving and pottery at KD 3.3., which described the interrelationship of the nature of the material and its utilization in everyday life, as well as the influence of the use of certain materials on human health. The tools and learning instruments used in this study are adapted from

the learning tools developed by Anisa (2016).

In the experimental class, teachers implemented learning using science learning tools integrated on the local potential of wood carving and pottery, whereas in control class, teachers carried out the learning process using commonly used learning tools (conventional).

The design model in this quasi-experimental study is the pretest-posttest control group. The students in both experimental and control classes were given pretest and posttest before and after treatment in the form of critical thinking skills. These critical thinking skills are in the form of questionnaires of 20 questions.

The technique of collecting data used in this study is testing techniques. The instrument used in data collection is in the form of test description which amounted to 20 questions to measure the critical thinking skills of class VIII SMP students.

The technique of data analysis used is descriptive analysis and inferential analysis using SPSS version 20 with the significance level of 0,05. Descriptive analysis is used to present the data of critical thinking skills in the experimental class (science learning integrated on the local potential of wood carving and pottery) and control class (conventional science learning) that have been obtained from pretest and posttest scores. The data analysis of critical thinking skills used in this study was average, highest score, lowest score, variance, and standard deviation.

In addition to the descriptive, analytical techniques, an inferential analysis is also conducted by using ANOVA to analyze the effect of science learning integrated on the local potential of carving wood and pottery to the critical thinking skills of class VIII SMP students. However, before ANOVA test, the prerequisite test is performed in the form of normality test and univariate homogeneity test. Normality test is used to find out whether the data come from the normally distributed population or not, while homogeneity test is used to determine whether the population of both groups is homogeneous or not.

The normality test is done on the pretest data of critical thinking skills which have been calculated with the hypothesis as follows:

$H_0$ : The data from the population that is normally distributed.

$H_a$ : The data from the population that is not normally distributed.

The normality tests were performed in each class, both experimental and control classes. The Kolmogorov-Smirnov normality test was performed using the SPSS 20 program at a 0.05



significance level. The criteria for performing a normality test at a significance level of  $\alpha = 0,05$  is data derived from a normally distributed population or  $H_0$  accepted if the value of significance is greater than the value of  $\alpha$  ( $.>$ ).

The homogeneity test is conducted to find out whether the population of both groups is homogeneous or not.

$H_0$ : The population of both groups is equal or homogeneous.

$H_a$ : The population of both groups is not equal or not homogeneous.

The Levene's Homogeneity Test was performed using SPSS 20 program at a significance level of 0.05. The criterion for conducting homogeneity test at level  $\alpha = 0.05$  is the population of both groups being equal or homogeneous, or  $H_0$  has accepted if the value of significance is greater than  $\alpha$  value  $\alpha$  ( $.>$ ).

After the two assumption tests above were met, then to analyze the influence of science learning integrated on the local potential of wood carving and pottery to the critical thinking skills of class VIII SMP students by using ANOVA.

The ANOVA hypothesis is as follows:

$H_0$ : The science learning integrated on the local potential of wood carving and pottery had no effect on the critical thinking skills of class VIII SMP students.

$H_a$ : The science learning integrated on the local potential of wood carving and pottery influenced the critical thinking skills of class VIII SMP students.

The ANOVA test was performed at 0.05 significance level with the help of SPSS 20 program. The acceptance or rejection criteria of  $H_0$  at the 0.01 significance level are:

- a.  $H_0$  is rejected if  $.<$ .
- b.  $H_0$  is accepted if  $.>$ .

**RESULTS AND DISCUSSION**

The results of the pretest and posttest descriptive analysis as a whole are shown in Table 1. Table 1 showed that the average pretest of critical thinking skills in the experimental class (54.83) is greater than the control class (54.33), and the posttest average of critical thinking skills in the experimental class (79,51) is larger than the control class (75,81).

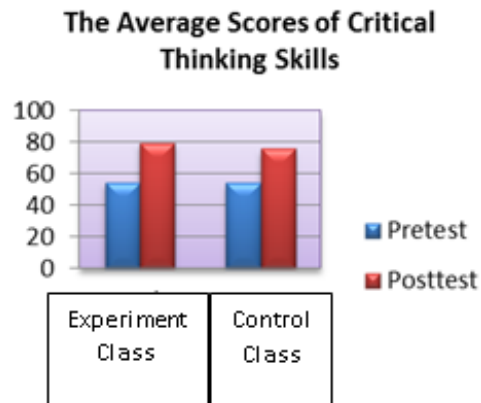
Based on the analysis, it can be seen that the average increase of students critical thinking skills of the experiment class is higher than the control class. This increase is due to the direct experience of student interaction with the pottery and furniture artisans who make the critical

thinking skills that students have become more excavated. Students became freer to ask about things they had not known before and made learning science more interactive and more meaningful. It is in line with the opinion of Machin (2014) which stated that the observation method is useful for the curiosity of the students so that the learning process has a high significance. It also agreed with Anisa (2016) who disclosed that science learning integrated with local potential would provide the students with an in-depth experience by engaging actively in the relevant environmental-related science (local potential) learning.

**Table 1.** The Results of Descriptive Analysis of Pretest and Posttest on the Critical Thinking Skills

Description	Experimen- tal Class		Control Class	
	pre- test	post- test	pre- test	post- test
The Number of the Subjects	32	32	30	30
Highest Score	68.89	94.44	67.78	87.78
Lowest Score	40.00	67.78	41.11	67.78
Average	54.83	79.51	54.33	75.81
Variance	66.56	29.78	64.32	26.88
Standard Deviation	8.16	5.46	8.02	5.18

The data of pretest and posttest of the critical thinking skills between the experiment class and control class also indicated that there is a different increase. The average comparison graph of the pretest and posttest scores on the critical thinking skills data between the experiment class and the control class is presented in Figure 1.



**Figure 1.** The Average Comparison of Pretest and Posttest of Critical Thinking Skills between Experiment Class and Control Class

Based on Figure 1 it can be concluded that the average pretest and posttest in the experiment class is higher than the control class.

Before the ANOVA test, a univariate assumption test is required. The univariate assumption test is the normality test and homogeneity test.

The Kolmogorov-Smirnov univariate normality test was performed on pretest data of critical thinking skills in experiment and control classes with SPSS 20 program. Based on the analysis of the normality test, it is obtained that the data came from the normally distributed population or  $H_0$  is accepted with  $>$  at the significance level of 0.05. The normality test results are presented in Table 2.

**Table 2.** The Results of Normality Test

Dependent Variable	The Pretest Data of Critical Thinking Skills	
	Sig.	Conclusion
Control Class	0.058	$H_0$ is accepted
Experiment Class	0.094	$H_0$ is accepted

The homogeneity test was performed using Levene's Test with the help of SPSS 20. The homogeneity test of the data can be concluded that the sample data that came from a homogeneous population if  $H_0$  is received with  $> \alpha$  at a 0.05 significance level. The homogeneity test result showed the sample data came from the homogeneous population. The univariate homogeneity test result is presented in Table 3.

**Table 3.** The Result of Homogeneity Test

Dependent Variable	The Pretest Data of Critical Thinking Skills	
	Sig.	Conclusion
Critical Thinking Skills	0.861	$H_0$ is accepted

The Levene's homogeneity test had also resulted in the conclusion that the sample came from a homogeneous population. Thus an ANOVA test can be performed. The result of ANOVA test on posttest data of critical thinking skills is presented in Table 4.

Based on the data, it can be concluded that the science learning integrated with the local potential of wood carving and pottery have an effect on critical thinking skill of class VIII SMP students. It is because the learning activities and visits made by students to the local potential of wood carving and pottery in Bantul District as

part of the learning process of science made students more active, and more critical in obtaining information directly from the craftsmen of wood carving and pottery. The science learning integrated with local potential provided a different experience for students and made learning more contextual and meaningful and provided a deep understanding for students. It is in line with the opinion of Anisa (2016) stated that science learning based on the local potential of wood carving and pottery is effective to improve the critical thinking skills of class VIII SMP students.

**Table 4.** The Result of ANOVA Test

Dependent Variable	The Posttest Data of Critical Thinking Skills	
	Sig.	Conclusion
Critical Thinking Skills	0.008	$H_0$ is rejected

## CONCLUSIONS

Based on the results of the research and discussion above, it can be concluded that the science learning integrated with the local potential of wood carving and pottery influenced the critical thinking skills of class VIII SMP students. This effect is indicated by a significance of 0.008 (significance  $< 0.05$ ).

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## THE IMPORTANCE OF TRAINING NEEDS' QUESTIONNAIRE TO ARRANGE SCIENCE TEACHER TRAINING PROGRAM

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### ABSTRACT

An ideal teacher training program is by participant's need. The major aim of this study is getting information about science teacher's perception and needs in their professional's life as a science teacher in Junior High School. The main idea of teacher training is to strengthen the integrated science of Natural Science concepts and problem-based learning. Data is gathered by spreading training needs questionnaire to 20 science teachers under an education foundation in Bandung. The questionnaire consists of six main parts which are teacher's profile, teacher's training, integrated science, problem-based learning, environmental problem and lesson preparation. The result of the training needs questionnaire is used as a basic of Science Teacher Training Program's Arrangement. There are four significant findings in training needs questionnaire. The first finding, the method of training is important. Most of the participant choose discussion method with sharing. The second finding, webbed model/ thematic approach in integrated science is unfamiliar for the participant. Therefore, the thematic approach can be a potential material for teacher training program. The third finding, 70% participants find obstacles in problem-based learning. This finding shows that the need to put problem-based learning material in teacher training program. The fourth finding, 65% participant, express opinions that material about lesson preparation is critical in teacher training. Based on the explanation above, we can conclude that training program for science teacher needs to be arranged according to teacher needs. So, the training program should use discussion method with sharing. Material about the thematic approach, problem-based learning and learning preparation are very potential to put into a training program for Junior High School science teacher.

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**Keywords:** training needs' questionnaire; science teacher; integrated science; problem-based learning

### INTRODUCTION

The ideal Science teachers have always been committed to developing science teaching as ongoing professional development opportunities. Teacher training is a form of professional development as a teacher. For teachers, professional development is a form of intellectual and personal endeavor in understanding new ideas about education, trying new learning activities and develop the practice of learning and self-confidence (Girvan et al., 2016). Therefore, the implementation

of science teacher training needs to be looked at the requirements and motivations of the science teacher. One effort that can be done to investigate the needs and motivation of science teachers is by distributing questionnaires the science teachers' needs. It is done to make the science teacher training well targeted and appropriate as needed. A good training program is one which by the needs of teachers in teaching science in the classroom.

According to Avalos (2010), professional development of the teacher learning, study on how to learn and transform teachers' knowledge into practice for the development of the students. The professional development is a complex pro-

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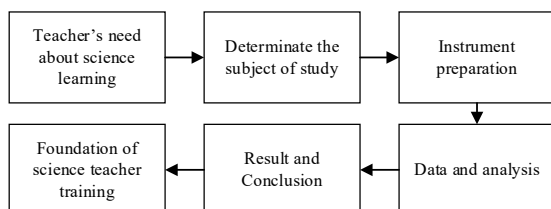


cess that requires the cognitive and emotional involvement of teachers. The teacher training is a part of professional development efforts. For teachers, the professional development includes personal hard work of intellectual and emotional, so that the teachers feel challenged.

The experiential learning is used in the professional development of teachers to develop classroom practice (Girvan et al., 2016). It can be a means of reflecting on learning through professional development activities. The teacher training is needed to support the ongoing professional development. The training is held as a form of professional development, sometimes organized by academic consultants or professional advisors (Aspfors & Fransson, 2015). In some countries, including Indonesia, the training is organized by the government and the private sector. Therefore, the teacher training will be effective if it fits the needs of teachers as a trainee. One way to capture the needs of science teachers is by distributing questionnaires. The main objective of this study was to obtain information on the perception of science teachers and their professional needs as a junior high science teacher.

## METHODS

This research is a descriptive research. The flowchart research is described in Figure 1.



**Figure 1.** The Research Flowchart

The data are obtained by distributing questionnaires to 20 participants (junior high school science teachers) under an Educational Foundation in Bandung. The high schools spread across 11 cities/regencies in West Java.

The research instrument is a questionnaire of training needs. The six parts of the questionnaire are:

1. Teacher's Profile
2. Teacher Learning
3. Integrated Science
4. Problem-based learning
5. Environmental Issues
6. Learning Preparation

The main mission of the questionnaires is

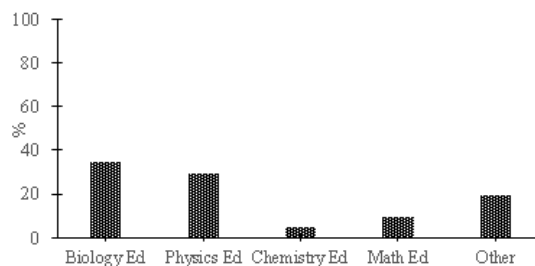
to identify the opinion of participants regarding a range of methods and training materials that appropriate with the needs of the participants. The questionnaires consist of 28 questions in the form of choices. The results of the questionnaires were analyzed to derive the basis for developing a training program for the junior high school science teacher.

## RESULTS AND DISCUSSION

This research was conducted in December 2016. The main purpose of the study is to collect information on the needs of teachers in training. The results are expected as a cornerstone for the junior high science teacher training program.

The subjects were the junior high science teacher in an educational foundation in Bandung. The teachers were grouped into five age groups; they were under 25 years old (10%), 25-29 years (20%), 30-39 years (30%), 40-49 years (25%) and 50-59 years (15%). It could be seen that the largest age group is 30-39 years group.

Pennings et al. (2014) revealed that the quality of teachers would be able to motivate the students. The educational background is an interesting topic to discuss (Figure 2). There are five types of educational background; they are Biology Education (35%), Physical Education (30%), Chemical Education (5%), Mathematics Education (10%) and Non-Educational background (20%). The interesting thing is that there is a Mathematics teacher who taught science.



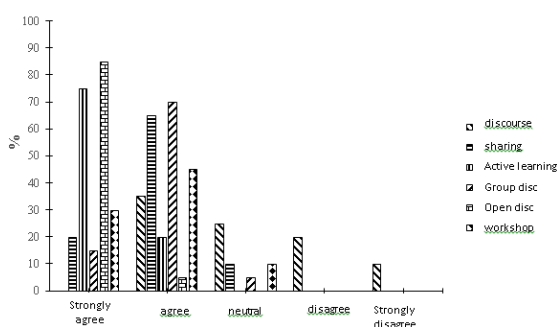
**Figure 2.** The Educational Backgrounds

The length of science teachers' experience in teaching is explored further through questionnaires. There are six groups of teachers' teaching years; they are the first year (10%), 2-5 years (30%), 6-10 years (15%), 11-15 years (5%), 16-20 years (15%) and >20 years (25%). The largest group is the group of 2-5 years of teaching and then followed by years of teaching of 25%. It became a potential regarding sharing experiences between teachers who have experience of >20 years with teachers who have fewer years

of teaching experience. Fernet et al. (2016) explained that teachers' teaching experience might be the greatest motivating factor in their career. The satisfaction of teaching of a teacher can also determine the orientation of a teacher's performance. It was disclosed by Skaalvik & Skaalvik (2013), namely that teacher performance can be supported by colleagues. If colleagues often hold discussions, the quality of learning will increase.

Claessen et al. (2016) in his study explained that a teacher confidence would increase along with the teaching experience. The important thing is the process of learning between teachers with lots of experience in teaching and novice teachers. The teacher educational background can determine the materials that will be taught to students (Blomeke et al., 2016). Therefore, it is needed to be held training to improve the knowledge of a science teacher. Sheldrake (2016) said that the background of teachers would increase teachers' confidence and motivation in performing his profession as a teacher.

A method of training will determine the effectiveness of a training program (Piper & Zuilkowski, 2015). The type of the desired method was discovered in the questionnaires of the science teacher training needs. Hendrickxa et al. (2016) also revealed that the training that used a social context and increased the discussions would produce an effective training. Based on Figure 3, the method of training which is expected by the respondents is an open discussion (85% of respondents strongly agree), active learning (75% of respondents strongly agree), sharing (65% of respondents agreed), group discussions (70% of respondents agreed). Therefore, these four methods will be used in the training of junior high school science teacher.



**Figure 3.** Teachers' opinions on the types of training methods

Hyry-Beihammera & Hascherb (2015) revealed that the teacher training would improve the performance of the educational process at school. Meanwhile, Girvan et al. (2016) revealed

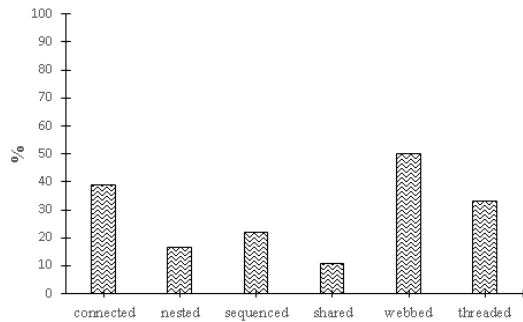
that the training by sharing experiences would help increase the professionalism of a teacher. Learning in the classroom is an important impact of the teacher training, Sledova et al. (2016) revealed that the communication factor in the teacher training is important. The active learning, discussion, and sharing methods can stimulate the communication between teachers and of course between teachers and students as a result of the training. The research conducted by Sukma and Ibrahim (2016) suggested that the active learning will improve the quality of learning.

Integrated science teaching in junior high school is the combination of the concept of Biology, Physics, and Chemistry. In the questionnaire, respondents were asked to select the type of integrated IPA that familiar with the integrated science teaching. Based on the analysis, 50% of respondents answered the type of webbed / networking is a model that is familiar. It can be a potential for deepening the integrated science material of the webbed type in the training of science teachers. The integrated science teaching in groups and independently allowed the search of overall concepts through learning (Parmin et al., 2015).

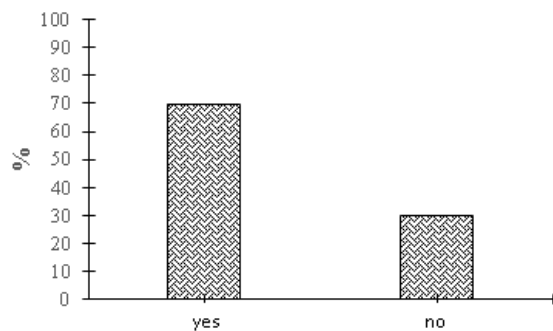
Science teacher must master the concepts of Biology, Physics, Chemistry in integrated science teaching. The confidence of a teacher is critical in front of science class (De Boer et al., 2016). To improve self-confidence, a science teacher must master each concept of science and science teacher training may be a useful tool. According to Park et al. (2006), a science teacher needed to develop the competence to implement the creativity of science learning through training programs. Creativity was related to one another in learning science. Through professional development programs, a science teacher can obtain refreshment and increase creativity (Park et al., 2006 & Pruski et al., 2013). According to Parmin et al. (2015), the scope of the concept of integrated science involved the concept of elements, energy, earth, universe.

The fourth section of the questionnaire is about the problem-based learning. As many as 90% of respondents knew about the problem-based learning. On the other hand, respondents find difficulties in implementing problem-based learning (70%). Figure 5 showed that the percentage of respondents who found obstacles in the implementation of problem-based learning is more than the respondents who did not. It may be potential to deepen the problem-based learning materials in the science teacher training program for the obstacles in the implementation of

problem-based learning problems can be reduced and found a solution.



**Figure 4.** The familiar types of integrated science



**Figure 5.** The obstacles in implementing the problem-based learning

According to Ermeling (2010), the professional development of teachers has been stressing on inquiry and problem-based learning. It aimed to enrich teachers with contextual issues and related to the school. The professional development should be collaborative, approach to the problem and is different from the conventional development program. A professional teacher can use problems in science learning, thus improving the ability of students to construct knowledge and its application (Winarsih & Mulya, 2012).

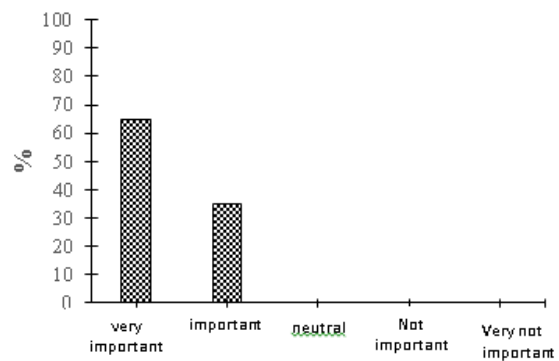


**Figure 6.** The learning model/approach that is difficult to be applied

Figure 6 showed that 70% of respondents found difficult to apply problem-based learning.

Incorporating problem-based learning in science teacher training may be potential. Problem-based learning is effective if students are learning in a group/collaborative (Zhang & Peck, 2003). The development of problem-based learning frequency can improve collaborative learning. Nariman & Chrispeels (2015) argued that students from different cultural backgrounds learned collaboratively in problem-based learning so that students will learn to solve contextual problems. The application of models/methods / strategies of learning science can be used, one of them was the environment content such as acid rain, pollution, greenhouse (Rubini et al., 2016).

The fifth part of the questionnaire aimed to determine the extent of respondents' opinions on the preparation materials for science learning in teacher training. It is intended to meet the pedagogical aspects of a science teacher training program. As many as 65% of respondents believed that the preparation of learning materials is very important to be trained in the science teacher training program.

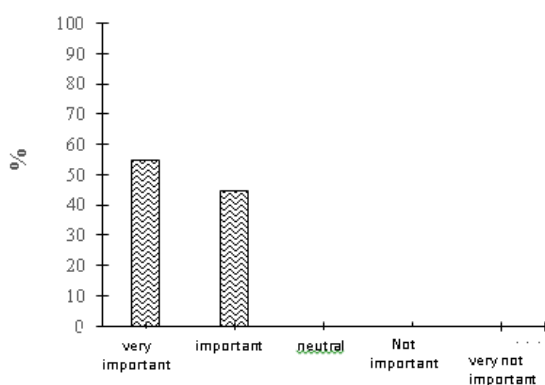


**Figure 7.** The opinions on the materials of learning preparation in training

The last question in the questionnaire is to find out the opinions of teachers about the importance of science teacher training. As many as 55% of respondents said science teacher training program is very important. Therefore, the science teacher training can be organized based on the needs of the respondents. There are no respondents who said that the science teacher training is not important.

Various studies on teacher training had been carried out. Aspfors & Fransson (2015) argued that teacher training is organized as professional development, sometimes carried out by the educational consultants or by the universities. Something similar happened in Scotland, the teacher training that organized by the authorities / local governments sometimes just for documen-

tation. In Japan, an induction program is compulsory, but the coach/mentor is not properly trained. Hyri-Beihammera & Hascherb (2015) also revealed that the training strategy should be in line with the education reform. It aimed to make training to be effective. The opportunities to improve the quality of teachers can be done through a professional development program (Lidqvist & Nordanger, 2016). Therefore, the development of teaching practices can be done through a professional development program (Ellis et al., 2015). Through a training program, teachers are expected to acquire knowledge and new insights about learning in school.



**Figure 8.** The opinions on science teachers training

## CONCLUSIONS

From the results of the comprehensive research, there are two main conclusions in this study. First, the training needs questionnaire can be used as the basis for the establishment of a science teacher training program so that the science teacher training programs will be on target and effective.

The second conclusion is about the contents and methods of the training. Based on the analysis of training needs questionnaire, discussion, sharing and active learning methods are the suitable methods for the needs of respondents. The materials that are potential to be presented in the science teacher training program are the thematically integrated science learning, problem-based learning, and preparation of integrated science teaching.

Based on the results and discussions, it is advisable for the organizers of the science teacher training program to learn the materials and methods of training required by science teachers. It is done to obtain the best science teacher training programs and agrees with the needs of science

teachers.

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## THE ANALYSIS OF STUDENTS SCIENTIFIC REASONING ABILITY IN SOLVING THE MODIFIED LAWSON CLASSROOM TEST OF SCIENTIFIC REASONING (MLCTSR) PROBLEMS BY APPLYING THE LEVELS OF INQUIRY

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### ABSTRACT

This study aims to determine the students' achievement in answering modified lawson classroom test of scientific reasoning (MLCTSR) questions in overall science teaching and by every aspect of scientific reasoning abilities. There are six aspects related to the scientific reasoning abilities that were measured; they are conservatorial reasoning, proportional reasoning, controlling variables, combinatorial reasoning, probabilistic reasoning, correlational reasoning. The research is also conducted to see the development of scientific reasoning by using levels of inquiry models. The students reasoning ability was measured using the Modified Lawson Classroom Test of Scientific Reasoning (MLCTSR). MLCTSR is a test developed based on the test of scientific reasoning of Lawson's Classroom Test of Scientific Reasoning (LCTSR) in 2000 which amounted to 12 multiple-choice questions. The research method chosen in this study is descriptive quantitative research methods. The research design used is One Group Pretest-Posttest Design. The population of this study is the entire junior high students class VII the academic year 2014/2015 in one junior high school in Bandung. The samples in this study are one of class VII, which is class VII C. The sampling method used in this research is purposive sampling. The results showed that there is an increase in quantitative scientific reasoning although its value is not big.

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**Keywords:** scientific reasoning; MLCTSR; levels of inquiry; science

### INTRODUCTION

Science (IPA) related to the natural way of finding out about a systematic manner so that IPA is not only a mastery of a collection of knowledge in the form of facts, concepts or principles but also a process of discovery (Allson in PMP IPA, 2014). Thus, students are trained to be able to find their various concepts studied thoroughly (holistic), meaningful, authentic, and active. One of the purposes of learning science is the development of scientific reasoning ability.

Scientific reasoning is important for scien-

ce, but the research by Koslowski (1996) indicated that many steps in the inquiry which is intended for scientific reasoning did not reflect the core attributes of scientific reasoning itself. Thus, scientific reasoning should be developed in students through the practice of scientific reasoning in a longer period and the more appropriate inquiry approach. (Chinn & Malhotra, 2002). Reasoning in problem-solving is to be developed in learning (H. Bancong, Subaer, 2013).

National Science Teacher Association and Association for the Education of Teachers in Science / NSTA & AETS (1998) stated that inquiry as for the development and use of higher order thinking. Scientific reasoning belonged to

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the high-level thinking skills related to the ability to identify, analyze and solve problems creatively and think logically so as to produce the proper consideration and decision; so that the scientific reasoning can be developed with the inquiry.

Based on direct observation in a junior high school in Bandung, it can be said that the purpose of learning science to develop scientific reasoning is less achieved. It is based on the findings of the following: 1) The results of the interview, conducted by one of the science teachers stated that classroom learning is not based on inquiry as a whole because it is still rare to experiment with, other than that there is difficulty in developing scientific reasoning because the type of questions used is still in the form of memorization and quantification, without ever trying to use standardized tests. So it did not require students to think higher and tend just to memorize formulas. Occasionally, the inquiry is conducted in learning but not fully engaged students in scientific inquiry and plan an experiment. Whereas, the scientific investigation and knowledge content are interconnected to underlie the development of scientific thinking. 2) The result of observations, made in the same school showed that the learning did not facilitate the development of scientific reasoning because, during the learning process, it has not been emphasized on the argumentative student's skills so that the students are less able to express their ideas. Besides, the learning process is focused on the delivery of content verbally and then write down the things that are considered important in the board. Although sometimes there are questions and answers in learning activities, only a few students that are actively involved. Also, the learning activities are rarely associated with the material being studied by its application in everyday life. So that students can develop skills that can be used outside the classroom, such as decision-making and problem-solving.

So, based on the results of the preliminary studies, it can be concluded that the learning activities have not been able to facilitate the development of scientific reasoning, especially in training and measuring appropriately. It causes the students unable to construct their knowledge independently so that the students' knowledge is less meaningful. Whereas, when students construct their knowledge, the learning will be more meaningful and can be remembered in the long run. Also, students are only able to solve problems and make decisions about the material being taught without being able to relate it to the application of the material. It causes the scientific reasoning ability of students to be low. The es-

sence of current IPA education reform is the shift from traditional teaching, low-level algorithmic thinking skills to learning that spur high-thinking skills such as reasoning (Rustaman, 2007). The development of reasoning ability and analytical thinking of students can be facilitated by the creativity of the teacher in developing the learning model (Saptono, et al., 2013).

An alternative solution that considered to solve the problem is by applying the inquiry model. Wenning (2005) explained that systematically inquiry affects the more effective process of knowledge transfer. Based on the background that has been disclosed above, the researchers are interested to know the development of scientific reasoning on integrated science learning using systematic inquiry model which is the levels of inquiry. The levels of inquiry models consist of six levels, started with the basic level to the highest level. These levels are discovery learning, interactive demonstrative, inquiry lesson, lab inquiry, real-world application and hypothetical inquiry (Wenning, 2010).

Scientific reasoning is defined as the students' cognitive abilities in five dimensions: serial ordering reasoning (students' ability in ordering data), theoretical reasoning (students' ability in applying theories to interpret data), functionality reasoning (students' ability in analyzing functional relation), control variables (students' ability to control variables), and probabilistic reasoning (students' ability in predicting based on data) (N. Shofiyah, 2013). Reasoning will support the use of information that was already obtained by students with information and commands in the matter of producing answers that reflect the mastery of related concepts (Nurdjani, 2012). The scientific reasoning referred to in this study is the ability to think and provide a reason through the activities of inquiry, experiment, drawing the conclusion based on facts and argument to compose and modify a theory about nature, as well as social (Bao et al., 2009). Scientific reasoning references used in this study are found in the Lawson framework which includes six aspects, namely the reasoning measured by conservatory reasoning, proportional reasoning, controlling variables, combinatorial reasoning, probabilistic reasoning, correlational reasoning (Lawson, 1994). However, the reasoning framework used in this study is the result of its development formulated by Jing Han (2011). The student reasoning abilities are measured using the Modified Lawson Classroom Test of Scientific Reasoning (MLCTSR). MLCTSR is a test developed based on a scientific reasoning test from Lawson's Classroom Test of

Scientific Reasoning (LCTSR) in 2000.

There are 24 double choice questions of two levels on LCTSR (Jing Han, 2011). Researchers modified it by the content based on the concept of science that is the motion that is tailored to the LCTSR assessment framework. However, the researchers only made 12 questions by the LCTSR indicator due to the results of discussions with the classroom teachers who did the teaching and asked to cut 24 questions into 12 without eliminating the aspect of scientific reasoning. This test is done twice on pretest and posttest.

The distribution of questions on each aspect used is based on the results of the development of the instrument; it can be seen in the table below:

**Table 1.** The Distribution of Questions on Each Aspect

Scientific Reasoning Aspects	Questions Number
Conservation of matter and volume	1,2
Proportional reasoning	3,4
Control of variable	5,6
Probability Reasoning	7,8
Deductive reasoning	9,10
Hypothetical-Deductive Reasoning	11,12

## METHODS

The determining of research method is based on the formulation of the problem and the purpose of research to be achieved. The research method chosen in this research is quantitative descriptive research method. This study described all activities, conditions, events, aspects of the component as they are and their picture using size or frequency. The only element of manipulation or collecting of the data provided is the study itself, which is done through observations, interviews, questionnaires or documentation studies (Sukmadinata, 2012: 73). Descriptive research not only stops on data collection, organizing, analyzing, and withdrawing interpretations and conclusions, but proceeds by benchmarking, seeking similarities, differences, causal relationships of various things because the discovery of meaning is the focus of the whole process. (Best, 1970, p. 117).

This study did not manipulate or alter the free variables but described a condition as it is. The depiction of conditions can be individual

or group, and use the numbers. The research design used is One Group Pretest-Posttest Design. In this design, there is no comparison or control group (Creswell, 1994, p. 130). Also, there is a pretest before the collecting of data so that the results of data collection can be known accurately because it can be compared before and after being given data.

The location used in this research is one of Junior High School (SMP) Negeri in Bandung. The reason the researchers chose the location because the school has a decent laboratory equipment, experimental tools in the school is quite complete and has been reacted for A, so researchers assumed the school is suitable for data collection.

This study aims to determine the development of scientific reasoning of junior high school students in integrated science learning by using the level of inquiry model. Therefore, the population in this study is all students of class VII SMP academic year 2014/2015 in Bandung. But due to the limited fund, human resources and time, the researchers only took samples from the population. The sample of this research is one of class VII that is class VII C.

The sampling method used in this research is nonrandom sampling that is the collection of sampling that did not give same chance for every member of the population to be selected to become the member of samples (Fraenkel, J.R., 2012, p. 94). The sampling technique used is purposive sampling that is taking the sample members of the population which are done with certain considerations.

Some of the considerations used as the reason for selecting the samples were recommendations from the teachers at the research location who knew the condition of the students that suggested the more easily conditioned classes and the students that were more active in learning. Their intelligent levels selected the students from 10 classes of the population based on their marks as a material for determining the samples. Then, the class that has the highest average score was selected as a representative sample.

In this study, all the problems of scientific reasoning used were derived from standardized tests, so that in the adaptation must be tested in advance to obtain a valid and reliable instrument. The test instrument analysis included the tests of validity, reliability, difficulty, and distinguishing. The test of the research instrument using states v4. Arif (2014) stated that states are an application program developed by Drs.Karno M.Pd and Yusuf Wibisono, ST that can calculate the analy-



sis of questions quickly, easily and accurately, let alone this application used Bahasa. States is capable of displaying several features and calculations including weighted data scores, test reliability, upper and lower groups, distinguishing power, difficulty level, correlation of question score with total score and quality of checkers.

The results of instrument experiment using rates from 12 questions that were used with the correct weight score are 1, and the weight of the wrong score is 0, then the average student score is 6.00, with a standard intersection of 1.89. The correlation of XY is 0.60, and the test reliability is 0.75.

**RESULTS AND DISCUSSION**

The students' scientific reasoning can be known quantitatively and qualitatively. Quantitatively, students' scientific reasoning is shown based on the pretest score and posttest score obtained by the students. While qualitatively, students' scientific reasoning is assessed in each sub-subject (each meeting) which emphasized the process from beginning to end in stages.

Scoring on scientific reasoning tests based on the scoring of tests made by Lawson (1994) is by way of the pair scoring schema. In this scoring, if students answered correctly between the content and the reason was given score 1. The scoring indicated that the students who were able to answer correctly between the content and the reason were considered to be able to solve the questions properly. If there is an error in the answer given either on the content or the reason, then the score is 0 and students were considered to be not able to solve the questions. Based on the scoring used, the student answers can form a pattern. There are four existing patterns, they are 1.1; 1.0; 0.1 and 0.0 patterns.

On Lawson's classroom test of scientific reasoning, combinatorial reasoning is replaced by correlational reasoning and hypothetical-deductive reasoning. This test is converted into a pure multiple-choice format containing 24 questions or 12 pairs between answers and reasons, so there are four questions for each aspect. In the original test, it can be seen the consistency because the

re are two pairs of questions for the same aspect with different numbers. In this study, scientific reasoning tests consisted of only 12 questions or 6 pairs. So, there is one question in the form of content and reason for every aspect of reasoning.

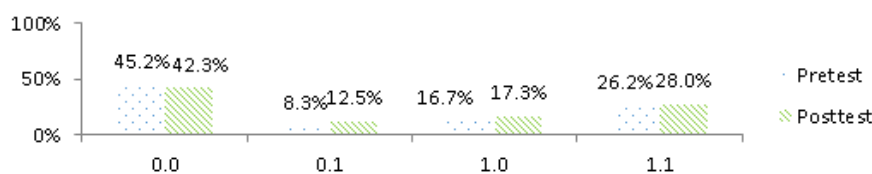
There is not found consistency in every aspect of scientific reasoning in this study. Therefore, the scientific reasoning scores are only one pattern, which is (1,1), (1,0), (0,1) or (0,0) without any pattern repetition in every aspect of scientific reasoning. So, the pattern of answers given by the students can not be compared with the findings of Jing Han (2011) which showed the level of consistency between questions and reasons. However, it still can be seen the image of scientific reasoning in every aspect without involving its consistency.

Student's scientific reasoning on the subject of linear motion can be determined by knowing the average value of pretest and posttest. Only the gain is used not with the effect size because there is no treatment in the research to see the increase. Meanwhile, to know the development of scientific reasoning is determined by the assessment of each meeting from the beginning of the data until the end, i.e., on the sub-subject of the irregular linear motion.

The students' scientific reasoning is obtained based on their reasoning patterns for both pretest and posttest that is presented in the following diagram.

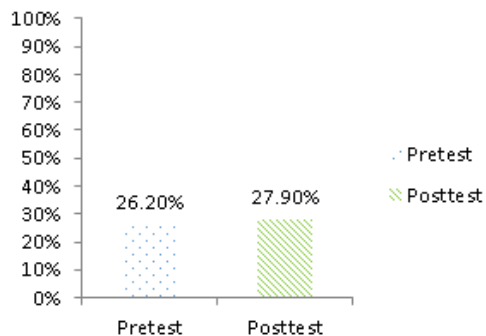
Based on the diagram it can be seen that in the pretest and posttests, the 0.0 pattern still dominated to be the highest, while pattern 1.1 is below the percentage of the pattern 0.0. It indicated that the pretest and posttest of the majority of students have not been able to answer the reasoning questions and its reasons correctly. For pattern 1.0 or one that answered correctly but wrong on the reason is more than the 0.1 pattern which did not answer correctly but got the right reason. The existence of students who answered the questions correctly but wrong on the reason or otherwise indirectly stated that there is a problem with the way students answer the questions.

The scientific reasoning can be seen as a whole from the pattern of 1.1 which showed the ability of students in solving the problem proper-



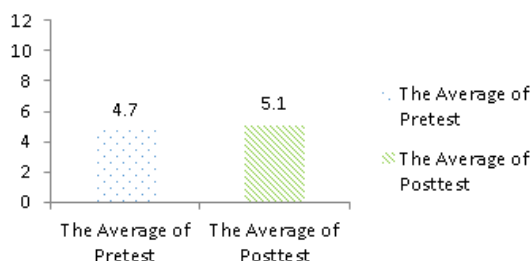
**Figure 1.** The Students' Answers on Scientific Reasoning Test Instrument

ly, it can also be seen from the average score of the students on pretest and posttest. Below it will be presented a figure of scientific reasoning on motion material. The percentage based on pattern 1.1 is as follows.



**Figure 2.** The Percentage Diagram of Scientific Reasoning

Based on Figure 2, the information obtained that the percentage of scientific reasoning with the 1.1 pattern only increased by 1.7%. It meant a small increase. In addition to the data above, the following will present a diagram of scientific reasoning based on the average posttest and pretest scores.

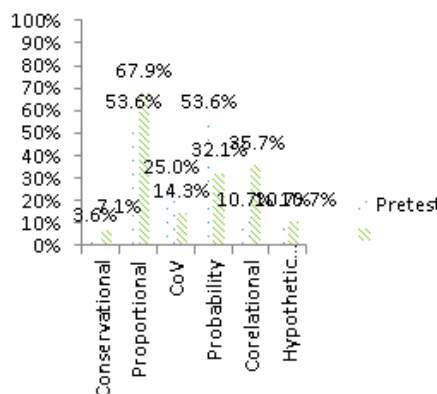


**Figure 3.** The Scientific Reasoning Diagram Penalaran Based on the Averages of Pretest and Posttest

Based on Figure 3, it is also obtained information that the scientific reasoning only has a difference of 0.4. So, it can be concluded quantitatively, either based on the 1.1 pattern or based on the average pretest and posttest score, there is an increase, but only a small increase. Because it only has a small difference too. The picture of the percentage of every aspect of scientific reasoning using pattern 1.1, in general, can be presented in the following diagram.

Based on Figure 4, it is found that the percentage of every aspect of scientific reasoning for pretest and posttest has different scores. There is a gain percentage 1.1 on pretest higher than posttest, but there is also the opposite. The higher

percentage gain of 1.1 in the pretest is control of variable and probability. It showed the problem of students in answering and solving the problems in the aspect of reasoning. As for the acquisition of a higher percentage of 1.1 in posttest is conservational weight, proportional reasoning, and correlational reasoning. As for hypothetic-deductive reasoning has the same number for the 1.1 pattern on pretest and posttest.



**Figure 4.** The Diagram of Scientific Reasoning Percentage on every Aspect

Quantitatively, the increase in scientific reasoning can be seen based on two components, namely the overall pattern of 1.1 and based on the difference in the average score of students. Based on the overall 1.1 pattern there is an increase in scientific reasoning ability of 1.7%, while based on the average score of students is 0.4. Although the increase is not large this indicated a change from before data collection, and after data collection, this did not indicate the treatment because students have previously used levels of inquiry.

Gradually, however, students continued to be trained with the levels of inquiry to improve their scientific reasoning. The increased scientific reasoning may be due to the students who have accustomed to the discovery-based learning so that they began to be able to construct their knowledge by using the level of inquiry model. It is in line with Wenning's expression (2011, p 17) which stated that:

“The level of inquiry models of science teaching is an approach to instruction that systematically promotes the development of intellectual and scientific process skills by addressing inquiry in a systematic and comprehensive.”

If viewed by the level of inquiry in the classroom that almost all activities were done and the active involvement of students based on the learning video can be another factor of the increase. Because students actively observed, defin-

ed variables and relationships, conducted experiments, communicated observations and made conclusions so students can construct knowledge independently.

If viewed on the percentage of students' scientific reasoning in every aspect, then the highest overall aspect is proportional reasoning while the lowest aspect is conservatory of weight. In the pretest, the highest aspect is proportional reasoning, as well as on the posttest. The lowest aspect is conservational of weight both on pretest and posttest. It can be attributed to the stages of levels of inquiry that has been trained, the proportional reasoning is an interactive demonstration, in which teachers were tasked with demonstrating, developing and asking questions, generating responses, asking for explanations so as to help students reach evidence-based conclusions. At this stage, the students have started to have a role based on real evidence of demonstration by the teachers. In contrast to the conservation of weight aspects trained in the early stages which is the discovery learning. The primary focus of discovery learning is to construct an inductive concept or knowledge acquired from the students' experience. At this stage, students have different experiences. It may be that the phenomenon at this stage is less appropriate to the students' experiences, or even the students have different experiences with the given presentation. Also, there may be difficulties for students to identify the relation between the phenomena given and their experiences.

The development of scientific reasoning required a lot of practice and patience because scientific thinking is a complete set of cognitive skills. It is critical for both teachers and researchers to understand how scientific skills developed. It can be seen where the percentage of LKS is just above 75% until the third meeting and not yet reached 80 even 90%. It indicated the development of students' scientific reasoning is also not maximally analyzed at the end of the meeting as the posttest. It is in line with the idea of Lawson (1979) which stated that the developmental view of intelligence, that intelligence is not only innate but how the ability of students' reasoning develops.

The development of scientific reasoning referred to a process or way of learning that built the students' knowledge of a particular concept that evolved over time. At the first meeting, basic ideas about the meaning of motion were developed with the levels of inquiry model with labs to build their knowledge independently. At the first meeting, scientific reasoning on the conservatio-

nal weight and proportional aspects are on score 8.7 which is trained with discovery learning and interactive demonstration. This score decreased at the second meeting. It is not a very important issue because at the third meeting there is an increase again. Neither did the other aspects of reasoning. Various problems arose because of the lack of time to examine the developments which take a long time because the process of development is repeated to determine the progress of learning because advances in learning will not occur naturally and required instruction.

Researchers have only three meeting times to collect the data by the time agreement given by the school, and this time is not enough to see the development of scientific reasoning over and over again. Besides, describing the development of scientific reasoning is not an easy thing because each student learned in different ways, only the general nature of the learning progress that can be used as research evidence. It is in line with Jing Han (2011, p. 118).

“To define a scientific reasoning learning progression, more work is needed. Defining a learning progression is not an easy task, particularly because each student learns in a different way but a common trait among learning progressions is that they are designed based on research evidence. “

## CONCLUSIONS

Based on the results of data analysis and discussions, it can be concluded that quantitatively there is an increase in scientific reasoning although the score is not high. The increase of scientific reasoning may be due to students being familiar with the discovery-based learning so that students began to be able to construct their knowledge by using the level of inquiry model.

The writer recommends several things, including 1) For teachers: the levels of inquiry model can be used as an alternative learning to train the scientific reasoning so that the students can construct their knowledge independently). For other researchers: It would be better if the instrument of scientific reasoning test is made to be four questions of each aspect so that it can be seen its consistency, 2) To be able to develop scientific reasoning takes a long time. Thus, the greater the learning pattern applied, the more scientific reasoning will develop.

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## PHYSICS LEARNING USING INQUIRY-STUDENT TEAM ACHIEVEMENT DIVISION (ISTAD) AND GUIDED INQUIRY MODELS VIEWED BY STUDENTS ACHIEVEMENT MOTIVATION

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### ABSTRACT

This study aims to determine the differences in learning outcomes of between students that are given the Physics learning models of Inquiry-Student Team Achievement Division (ISTAD) and guided inquiry, between students who have high achievement motivation and low achievement motivation. This study was an experimental study with a 2x2x2 factorial design. The study population was the students of class X of SMAN 1 Toroh Grobogan of academic year 2016/2017. Samples were obtained by cluster random sampling technique consists of two classes, class X IPA 3 is used as an experimental class using ISTAD model and class X IPA 4 as the control class using guided inquiry model. Data collection techniques using test techniques for learning outcomes, and technical questionnaire to obtain the data of students' achievement motivation. Analysis of data using two-way ANOVA. The results showed that: (1) there is a difference between the learning outcomes of students with the ISTAD Physics models and with the physics model of guided inquiry. (2) There are differences in learning outcomes between students who have high achievement motivation and low achievement motivation. (3) There is no interaction between ISTAD and guided inquiry Physics models learning and achievement motivation of students.

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**Keywords:** ISTAD; guided inquiry; achievement motivation; learning outcome

### INTRODUCTION

One of the main educational goals is to teach about the nature of science that students should be involved in the investigation and produce a product in the form of facts, concepts, principles, theories, and laws (Zeidan & Jayosi, 2015). The essence of science consists of four elements, namely science as a process, science as a product, science as an attitude and science as an application. The essence of science could be developed, one way to do it is using Physics.

Physics is the science that deals with the discovery and understanding of the fundamental

laws that moving matter, energy, space and time. Hence, some students feel scared, and depressed in understanding the concepts and formulas of Physics that are considered to be arduous (Sugianti, 2005).

Physical Education should be taught according to characteristics of Physics through direct measurement, the use of the experimental method, demonstration, and elaboration of the formula (Subekti & Ariswan, 2016). But in reality, often encountered high school students with learning difficulties on Physics, complained that studying Physics is very difficult.

One model of learning that can help students find the concept and use the process of science is guided inquiry learning model (Yager

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& Akcay, 2010). Guided inquiry learning is based on the context of the problem, determining the problems and the stages of its solution, the teacher guided the students to perform activities by providing the initial questions and lead a discussion (Abdelraheem & Asan, 2006). The inquiry is a way to study scientific issues in the context of real life (McBride, et al., 2004).

Guided inquiry is a learning process which overall activities carried out by students such as planning investigations, making observations, analyzing, interpreting data, suggesting answers, formulating conclusions and communicating; while the teachers acted as motivators that guided and gave good instructions through either a fully procedure or guiding questions during the proceedings (Banchi & Bell, 2008).

Guided inquiry learning, teachers must be able to design a learning method that actively involved students. At the beginning of the learning activities, the teacher gave a lot of guidance then regularly reduced it so that the students could be good investigators and their scientific knowledge could be achieved (Yunus, et al., 2013).

Guided inquiry has been widely applied in the learning process to improve the process and learning outcomes of students. Vlasi's & Karaliota's study (2012) showed that the guided inquiry could improve learning outcomes of students and increase the confidence of teachers in teaching science. Setiawan, et al. research (2016) also showed that the inquiry-based learning is effective to improve the learning outcomes, the enthusiasm of the students in following the activity of the practices, and the attitudes of students in learning process. Meanwhile, the application of CTL guided by guided inquiry model can improve the learning outcomes and students liveliness (Fitriani, et al., 2016).

Inquiry learning model has been applied in SMA Negeri 1 Toroh Grobogan Regency. However, the acquired learning outcomes of the students are still not optimal. Therefore, it needed to be modified by incorporating inquiry learning model with a student team achievement division (STAD).

STAD consists of five main components, namely a class presentation, study groups, individual tests, score development and group awards (Kordaki, et al., 2012). STAD has been widely implemented in the learning process to improve the learning outcomes of students; it is shown from the results of Tiangtong's & Teemuangsai's research (2013), which indicated that the STAD could improve learning outcomes and collaboration skills among students. These results are also

supported by Mahbub Z, et al. research (2016) which indicated that the cooperative learning of STAD assisted by animation media could improve cognitive learning outcomes of students.

The learning model of STAD is a syntax blending between STAD cooperative models with the syntax of guided inquiry. Most of the syntax of inquiry is included in the group work phase in the syntax of STAD, whereas before the evaluation phase of individual and group awards, STAD learning model is included in the repetition stage inquiry learning. Thus, ISTAD learning strategy can be regarded as the activities of inquiry in the group work (Prayitno, 2010).

ISTAD contains two power needed for physics learning, they are the excess guided inquiry as a learning process to enable students in the activities of scientific investigation and STAD directing students to learn independently with their group in order to achieve common goals and by giving rewards to the outstanding group is expected to increase students' motivation (Erina & Kuswanto, 2015).

Results of research by Abdullah & Shariff (2008) showed that the inquiry learning guided by cooperative learning is more effective in increasing the students understanding of the concept, while research by Bilgin (2009) showed that students using guided inquiry learning assisted by cooperative learning have a better understanding of concepts and attitudes. Thus, ISTAD application can be used as a solution to increase the students learning outcomes of Physics.

The success of Physics learning is influenced by various factors, one of which is the motivation. McDonald in Syaiful Bahri (2003: 114), stated that motivation is an energy change within the person characterized by effective arousal and anticipatory goal reactions. These changes of energy in a person's self is in the form of a real activity which is a physical activity. In the process of learning, motivation is very necessary because someone who did not have the motivation to learn, would not be possible to do the learning activities so that the students learning achievement would not also be good.

Achievement motivation is the encouragement related to the achievement that is the desire of a person to master the obstacles and maintain a competitive, high-quality work through hard efforts to exceed past deeds and outperform others (Lindgren, 1976: 67).

Achievement motivation can provide a very substantial contribution to the efforts of students to obtain optimal learning results. It is by the opinion of McClelland (1987), achievement

motivation is an urge or desire to do everything as best as possible, not to gain social respect or prestige, but to achieve personal fulfillment in themselves. Besides, McClelland also stated that individuals who have high achievement motivation, when faced with complex tasks tend to do well. If he completed a complex task, it would make him more enthusiastic to accomplish the harder task better than before.

It is reinforced by the results of research by Sujarwo (2011) that the achievement motivation affected the acquisition of learning outcomes. Students who have high achievement motivation obtain better learning outcomes than the students who have low achievement motivation.

## METHODS

The study was conducted in SMA Negeri 1 Toroh Grobogan Regency, which addressed on Jl. Raya Purwodadi-Solo km 07 Sindurejo village, Toroh Subdistrict, Grobogan Regency, Central Java, in the first semester of 2016/2017. As for the timing of the research, it started from the formulating of the proposal to a research report, beginning in July 2016 until March 2017.

This research uses quasi-experimental methods on the basis that this study sought to determine the effect of one variable to another variable and take samples of two classes.

This study is an experiment with a 2x2x2 factorial design. Two-way ANOVA was examining the influence of the main factors and interaction factors by classifying variables into two models; they are ISTAD and guided inquiry learning. A moderator variable is the achievement motivation which is categorized into two, namely achievement motivation high and low categories.

The population in this study were all students of class X IPA SMA Negeri 1 Toroh, Grobogan Regency of 2016/2017 academic year consisting of four classes with the number of students 40 per class. Sampling was done by cluster random sampling then obtained two classes as samples treated differently. Sampling was done randomly, and then computed the mean difference of the population. The data used is the value of Middle Semester Exam (UTS) of the odd semester of the academic year 2016/2017. The statistical test used was t-test (two-tailed). Calculations were performed using SPSS 20. Results of statistical tests using t-test acquired one class as the experimental class, which is class X IPA 3 by using ISTAD model and class X IPA 4 as a control class using guided inquiry learning model.

Data collection techniques in this study are

using: (1) the documentation technique to determine the early ability of students. The obtained data of prior knowledge is the value of Middle Semester Exam (UTS), (2) the questionnaire technique with Likert scale to determine the level of achievement motivation of students in learning physics, which are divided into high and low categories, (3) the test technique to determine the learning outcomes of knowledge, (4) the observation technique is used for observation of attitudes and skills of students during the learning process.

Instruments used are in the form of syllabi, lesson plans and data collection instruments are in the form of tests and observation sheet. The test instrument is used to measure the results of a test study of knowledge. It used a multiple choice test for questions of knowledge. Observation sheet is used to measure the learning outcomes of attitudes and skills when learning process took place.

Instrument validation test is performed by an expert before tested, including lecturers and education practitioners. After testing the instrument of learning outcomes of knowledge, testing the validity, reliability, level of difficulty and test of distinguishing problems are performed using QUESS program.

The test of data normality is using the Kolmogorov-Smirnov test; the homogeneity test is using Bartlett test. Hypotheses are tested using univariate ANOVA test aided with SPSS 20 software.

## RESULTS AND DISCUSSIONS

The data of students learning outcomes is obtained from students test results of circular motion material that is given after receiving treatment. The data of students learning outcomes is presented in Table 1 for the overall data research class, Table 2 for the data of ISTAD class learning outcomes and Table 3 for the data on the guided inquiry class. The following learning outcomes data presented in Table 1.

**Table 1.** The Description of Students Learning Outcomes Data

Class	Sum of Data	Highest Score	Lowest Score	Average	(SD)
ISTAD	40	93.5	68	81,12	6.63
Guided inquiry	39	83	61.5	74.56	5.34

Table 1. is the description of the students

learning outcomes data in both of the experimental classes. Based on Table 1. it showed that the highest score of students in ISTAD class is 93.5, a bit higher than the highest score in guided inquiry class that is equal to 83. The lowest score on ISTAD class is 68 which is higher than the lowest score of guided inquiry class that is 61.5. The average of learning outcomes in ISTAD class is 81.12, and the average of learning outcomes in guided inquiry class is 74.56.

Table 1 also showed that the students learning outcomes in ISTAD class are higher than guided inquiry to. The difference in learning outcomes scores between these two classes is 6.56. The highest scores between these two classes have the difference value of 10.5, the highest score of ISTAD class is higher than the highest score of guided inquiry class. The lowest score of guided inquiry class is lower than the lowest score of ISTAD class with the odds of 6.5.

The frequency distribution of learning outcomes of ISTAD class and guided inquiry class is described in Table 2 and Table 3.

**Table 2.** The Frequency Distribution of Students Learning Outcomes of ISTAD Class

Interval	Middle point	Absolute frequency	Relative frequency %
60-64	62	0	0
65-69	67	2	5
70-74	72	4	10
75-79	77	10	25
80-84	82	9	22.5
85-89	87	10	25
90-94	92	5	12,5
95-99	97	0	0
Total		40	100

The frequency distribution of scores in Table 2 is divided into eight classes or interval of values. The highest class is in the interval of 75-79 and 85-89 with the number of students who score at the interval as much as 10 students, or approximately 25% of students, as well as the smallest frequency in the 65-69 interval, is 5% with the number of students as much as 2 student.

The frequency distribution of scores in Table 3 is divided into eight classes or interval of values. The highest class is in the interval of 75-79 with the number of students who score at the interval as much as 17 students, or approximately 43.59% students, as well as the smallest frequency in the interval 60-64, is 2.56% with the number of

students as much as 1 student.

**Table 3.** The Frequency Distribution of Students Learning Outcomes of Guided Inquiry Class

Interval	Middle point	Absolute frequency	Relative frequency %
60-64	62	1	2.56
65-69	67	7	17.95
70-74	72	7	17.95
75-79	77	17	43.59
80-84	82	7	17.95
85-89	87	0	0
90-94	92	0	0
95-99	97	0	0
Total		39	100

The students' achievement motivation data is obtained from motivation questionnaire in the form of a checklist with the Likert scale that is given to the students. The achievement motivation questionnaires are given to the experimental class with ISTAD learning model and control class that used guided inquiry model. The student's achievement motivation is categorized into two, high and low. Students are considered to have a high achievement motivation if the achievement motivation score is more than or equal to the average score of all samples. Students are categorized as having low achievement motivation if the achievement motivation score is below the average score of all samples. The student's achievement motivation data of high capability category is presented in Table 4.

**Table 4.** The Description of Students Achievement Motivation Data

Learning Model	S	Average		The Number of Students		Cut off
		High	Low	High	Low	
Guided inquiry	39	4,37	3,67	19	20	4,02
ISTAD	40	4,33	3,73	27	13	

The student's achievement motivation scores in Table 4 are categorized into the criteria of high and low averages. The total average is accumulated from both classes. Grouping the categories of high and low achievement motivation is based on the total average of the score which is 4.02, so this score is used as a cut-off or the limit of the average score. If the students have an



average score more than or equal to the cutoff, then the achievement motivation of the students is categorized as high. If the students have an average score less than 4.02, then the achievement motivation of the students is categorized as low.

The average score of high achievement motivation for ISTAD class and guided inquiry class based on Table 2 has a difference of 0.04. The average score of high achievement motivation for guided inquiry class is higher than the average score of ISTAD class. However, the number of students who have high achievement motivation for ISTAD class is more than guided inquiry class. The average score of low achievement motivation for ISTAD class and guided inquiry class based on Table 2 has a difference of 0.06. The average score of low achievement motivation for guided inquiry class is lower than the average score of ISTAD class. Also, the number of students who have low achievement motivation for ISTAD class is less than guided inquiry class. From Table 2 it can be concluded that the achievement motivation of students for the class that has been given ISTAD learning model is better than the class that has been given guided inquiry learning model.

The frequency distribution of high achievement motivation is described in Table 5, and Table 6 presented the frequency distribution of low achievement motivation.

**Table 5.** The Frequency Distribution of High Achievement Motivation

Class Interval	Frequency	
	Absolute	Relative %
181-195	22	47,83
196-210	21	45,65
211-225	3	6,52
Total	46	100

The frequency distribution that is being presented in Table 5 showed that the greatest frequency of high achievement motivation lies in the interval of 181-195 and the smallest frequency of high achievement motivation is in the interval of 211-225. The percentage difference between the high and low achievement motivation is 39.13%.

The frequency distribution that is being presented in Table 6 showed that the biggest frequency of low achievement motivation is in the interval of 166-180 about 69.70%, and the smallest frequency of low achievement motivation is in the interval of 135-150 about 9.09%.

**Table 6.** The Frequency Distribution of Low Achievement Motivation

Class Interval	Frequency	
	Absolute	Relative %
135-150	3	9.09
151-165	7	21.21
166-180	23	69.70
Total	33	100

Based on the prerequisite test analysis that has been done, it was concluded that a random sample of data observations came from a normally distributed population and homogeneous. The conclusion indicated that the prerequisite test analysis for ANOVA test had been met. Thus the hypothesis test analysis using ANOVA technique can be resumed. ANOVA test was performed using univariate ANOVA aided by SPSS 20, with a significance level of 5%. Hypothesis test results are summarized in Table 7.

**Table 7.** Hypothesis Test Results Summary

Hypothesis Test	Sig.	Final Score Sig.	Conclusion
Learning Process	0.000	0.00<0.05	H <sub>0</sub> rejected
Achievement Motivation	0.000	0.00<0.05	H <sub>0</sub> rejected
Learning model– Achievement motivation	0.635	0.635>0.05	H <sub>0</sub> accepted

Based on the data in Table 7, it can be concluded about hypothesis testing as follows:

The first hypothesis related to the influence of the learning model to the students learning outcomes. The hypothesis testing is aimed to determine the differences in learning outcomes between students who get ISTAD learning model as an experimental class and guided inquiry learning model as the control class. The results of data analysis obtained significance value 0.000 < 0.05, thus H<sub>0A</sub> is rejected, and H<sub>1A</sub> is accepted. The analysis results showed the differences in the results between students who get ISTAD model and guided inquiry model in learning Physics.

The results are consistent with the research by Erina & Kuswanto (2015) which showed that there is a significant influence of ISTAD learning model in improving students learning outcomes in Physics and line with the research by Iswandari, et al. (2013) stated that ISTAD significantly affected the science process skills and students

learning outcomes in biology.

The research by Nurhidayati, et al. (2015) also showed that the combined STAD combined with guided inquiry method could increase the activity and learning outcomes of students with a very high percentage.

The students who got ISTAD learning model obtained higher learning outcomes in the aspects of knowledge compared with the students who got a guided inquiry learning model. The average of learning outcomes of knowledge at ISTAD class is 81.13, while the average of learning outcomes in guided inquiry class is 74.56.

The second hypothesis is related to the differences in learning outcomes based on students achievement motivation. The testing of this hypothesis is aimed to determine the differences in learning outcomes between students who have high achievement motivation and students who have low achievement motivation. The results of data analysis obtained significance value  $0.000 < 0.05$ , thus  $H_{0A}$  is rejected, and  $H_{1A}$  is accepted. The analysis results indicated that there are differences in learning outcomes between students who have high and low achievement motivation. High achievement motivation and low achievement motivation is categorized based on the cut-off score of 4.02.

The average score of high achievement motivation in the experimental class is 4.33, lower than the control class which is 4.37. There is a difference of 0.04. However, the number of students who have high achievement motivation in the experimental class is more than the control class. In the experimental group, the number of students who have high achievement motivation was 27 students, while the control class only 19 students.

The average score of the low achievement motivation in the experimental class is equal to 3.73, higher than the control class of 3.67. The number of students who have low achievement motivation in the control class is also more than the experimental class. At control class, the number of students who have low achievement motivation was 20, while the experimental class is 13 students.

These results are consistent with the research conducted by Sugiyanto (2009), stated that achievement motivation contributed to the students' academic achievement positively and significantly. The research conducted by Sukimarwati, et al. (2013) also stated that the achievement motivation gave influences on students' achievements and in line with Wiratama's research (2014) that indicated that there are differen-

ces in learning outcomes of students who have high and low achievement motivation.

The third hypothesis is related to the interaction between learning model and students achievement motivation. The testing of this hypothesis is aimed to understand the interaction between ISTAD and guided inquiry learning models with students achievement motivation. Based on the testing results, it is concluded that there is no interaction between ISTAD and guided inquiry learning models with students achievement motivation. It is influenced by several factors.

First, the learning outcomes of knowledge between methods of learning and achievement motivation are stand-alone and unrelated. Students who have high or low achievement motivation did not provide the interaction of the learning models. Students who have high achievement motivation if treated with any model will have good learning outcomes. Conversely, students who have low achievement motivation will have diminished learning outcomes if treated with any model.

Second, on the learning outcomes, the interaction attitude between learning model and achievement motivation did not give a significant effect because students who have high and low achievement motivation followed the learning process well from the beginning to the end.

Third, on the result of learning skills, students have a natural reaction in participating in learning activities to prepare a presentation, equipment, and materials in the lab, and do pay attention to the lab work. Students who have high and low achievement motivation equally gave good responses. Thus, it can be concluded that there is no interaction between the models of learning and achievement motivation on learning outcomes' aspects of knowledge, attitudes, and skills. Students who have high and low achievement motivation will be equally able to cope well.

## CONCLUSION

The results of this study can be concluded that: 1) there is a difference between students learning outcomes that were given ISTAD learning model and guided inquiry learning model in learning Physics. ISTAD learning model provided better learning outcomes than guided inquiry learning model. 2) there are differences in learning outcomes between students who have high and low achievement motivation. The students who have high achievement motivation got better learning outcomes compared to the students who have low achievement motivation. 3) there is no

interaction between ISTAD and guided inquiry learning models with students achievement motivation. Learning models and achievement motivation are different, so if given a different learning model, students who have high achievement motivation will get better learning outcomes than students who have low achievement motivation.

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## ADDRESSING AN UNDERGRADUATE RESEARCH ISSUE ABOUT NORMALIZED CHANGE FOR CRITICAL THINKING TEST

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### ABSTRACT

Normalized change is a familiar expression used to measure student's improvement in physics education research, including critical thinking skill improvement. A widely used standardized critical thinking test is the Cornell Critical Thinking Test. The CCTT scoring method, rights minus one-half the number wrong, results from possible interval scores ranging from the negative minimum score to positive maximum score. The problem then arises in the use of the normalized change in CCTT scores, particularly in the situation when the post-test score is worse than the pre-test score. We reveal the used equation deficiencies and demonstrate the mistakes made by undergraduate researchers, as well as suggesting a modified equation that can be used under the normalized change rationale, i.e. the ratio of the gain or the loss of the maximum possible gain or loss. Some frequently asked questions about normalized change are also discussed.

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**Keywords:** normalized change; physics education; undergraduate research; Cornell critical thinking test

### INTRODUCTION

The expression of normalized gain has been widely used in physics education research since it was first proposed by Hake (1998a). The normalized gain for treatment is defined as the ratio of the actual gain  $G$  (refers to the difference between the post-test score and the pre-test score) to the maximum possible gain  $G_{max}$ . The 'Hake gain' is used by instructors, who want to see how much conceptual learning their students achieve, and by researchers, who want to compare the difference in conceptual learning between groups exposed to different pedagogies (Lasry et al., 2014; Hoelwarth et al., 2005; Potter et al., 2014; ). It is also considered as a rough measure of the effectiveness of a course in promoting conceptual understanding (Hake, 1998a; 2002; Meltzer

and Manivannan, 2002; Von Korff et al., 2016; Berek et al., 2016), scientific literacy (Afriana et al., 2016; Khaeroningtyas et al., 2016), and the effectiveness of a course curriculum (Colt et al., 2011), a developed learning material (Putra et al., 2016; Triyuni, 2016), online homework system (Cheng et al., 2004), and studio physics format (Cumming et al., 1999; Sorensen et al., 2006; Sorensen et al., 2011; Kohl & Kuo, 2012).

Along with the development of physics education research, some limitations were found in Hake's equation (see Marx and Cummings, 2007). In particular, when the post-test score is worse than the pre-test score, the 'Hake gain' permits ambiguous interpretation of the result. For example, when the average pre-test score  $\langle S_{pre} \rangle$  on the certain exam is 90%, and the average post-test score  $\langle S_{post} \rangle$  on the same exam is 75%, it would give an average normalized gain  $\langle g \rangle$  of  $-1,5$  by using Eq. (1).

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$$\langle g \rangle \equiv \frac{\% \langle G \rangle}{\% \langle G \rangle_{max}} = \frac{(\% \langle S_{post} \rangle - \% \langle S_{pre} \rangle)}{(100 - \% \langle S_{pre} \rangle)} \quad (1)$$

This situation is often not understood well by undergraduate researchers. Regardless of whether or not they grasp the consideration of the difference in use the class-average normalized gain  $\langle g \rangle$  and the average of the single-student gains  $g_{ave}$  by Hake (1998), undergraduate researchers tend to use the less appropriate equation, or they easily eliminate the anomaly data to simplify calculations. It certainly can lead to misinterpretation of the students' performance on the conceptual change after the instruction. Even an effective learning scenario by the experienced teachers might not improve student scores (Cumming et al., 1999) or can produce the post-test score is less than the pre-test score. The latter has likely happened if the students shift their correct answer of the certain item in the pre-test into the incorrect answer of the same item in the post-test, as reported by Lasry et al. (2014).

This deficiency leads Marx and Cumming (2007) proposed a formula called as the normalized change  $c$  to complete the 'Hake gain' equation. The normalized change measures all possible changes in students' performance after the instruction with Eq. (2), where the post and pre refer to the student score out of 100%, respectively. In the situation where the post-test score is less than the pre-test score defined as the ratio of the loss to the maximum possible loss, measured by Eq. (2d).

$$c = \begin{cases} \frac{post - pre}{100 - pre} & post > pre & (2a) \\ drop & post = pre = 100 = 0 & (2b) \\ 0 & post = pre & (2c) \\ \frac{post - pre}{pre} & post < pre & (2d) \end{cases}$$

However, Eq. (2d) needs more attention when applying directly to the raw score, in particular case ranged from negative to positive scores, such as a raw score of The Cornell Critical Thinking Test (CCTT) level X and level Z (Ennis & Millman, 2005). One of the recommended scorings of Ennis et al. (2005) for both level X and level Z test is a total score using the formula rights minus one-half the number wrong. Therefore, level X test, for example, which has 76 items (including 5 sample items), then all the possible total scores ranged from -35.5 to 71. Consider a worst case (although it is impossible, only showing an ambiguous interpretation of the result) in which

the pre-test raw score is 71, and the post-test score is -35.5 on the CCTT level X. An undergraduate researcher using Eq. (2d) Would assign a normalized change of -1.5. It can make undergraduate researchers who are not aware of this situation confuses or present a wrong data interpretation.

This paper highlights the issue above as well as addresses some issues about normalized change (we prefer to use the term 'normalized change  $c$ ' than 'normalized gain  $g$ ' in this paper) in undergraduate educational research. There are some adequate and important points to be discussed which often becomes frequently asked questions by an undergraduate educational researcher. This paper will help undergraduate researchers understand well the normalized change to avoid misinterpretation of the data.

### Outline of Previous Research

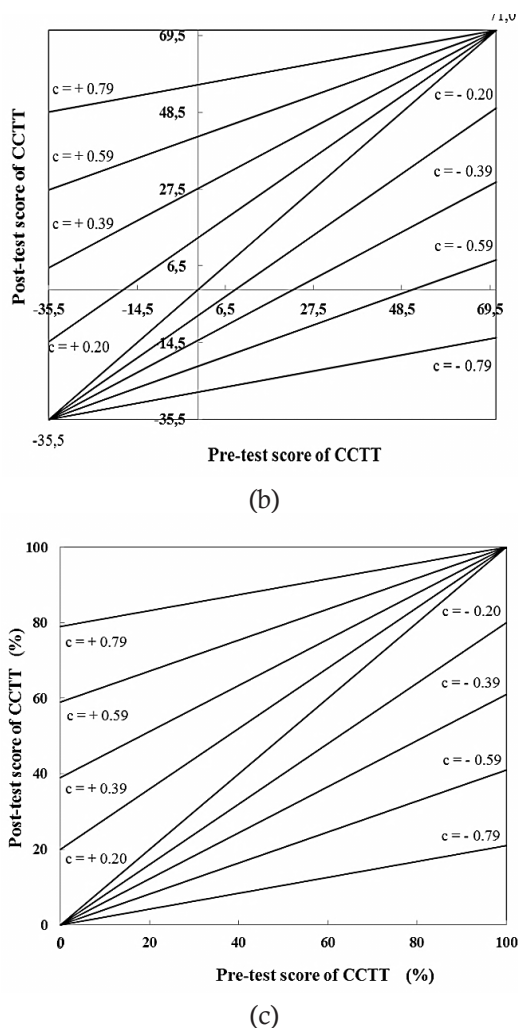
Houveland et al. (1949) introduced a parameter independently for measurement of percentage change, who called  $g$  as the "effectiveness index." While Gery (1972) named  $g$  as the "gap-closing parameter." Hake (1998a,b) in his large student survey of mechanics test data for introductory physics courses, again familiarized  $g$  as the "normalized gain" expressed by Eq. (1) and Cohen et al. (1999) called  $g$  different than the others, namely "POMP - Percentage Of Maximum Possible".

In his study, Hake (1998) prefers to introduce the class-average normalized gain  $\langle g \rangle$  than the average of the single-student gains gave to characterize a group's improvement (see Hake, 1998 for Hake's considerations). Eq. (1) employs the average class pre-test and post-test scores for obtaining  $\langle g \rangle$ , while  $g_{ave}$  utilizes the single-student gain  $g$  which characterizes an individual's improvement, as shown in Eq. (3), where pre and post refer to the student score out of 100%, respectively. The comparison of these two methods in calculating the average  $g$  and how this comparison may be able making inference about how a group of students has changed as a result of instruction discussed carefully in Bao's paper (2006).

$$g_{ave} = \frac{1}{N} \sum_k g_k = \frac{1}{N} \sum_k \frac{post_k - pre_k}{100 - pre_k} \quad (3)$$

The 'Hake gain' then became widely used equation by the instructors and the researchers, then Marx and Cummings (2007) found some limitations of using  $g$  and  $\langle g \rangle$ , as well as proposing the calculation of the normalized change  $c$  in Eq. (2). The normalized change also encom-





**Figure 1.** Lines of equal  $c$  for various CCTT pre-test and post-test raw score combinations, calculated (a) using Eq. (2d) for the loss and Eq. (4a) for the gain, (b) using Eq. (4), as well as (c) percentage score using Eq. (2).

**An Illustrative Example of the CCTT scores**

We present an illustrative example from student’s CCTT raw scores in Table 1 to demonstrate the problem and given approaches. The scores are randomly selected only to highlight the differences between the usual approach used by undergraduate researchers and the proposed approach.

Table 1 shows the differences between single-student normalized change scores, particularly when student post-test score is less than pre-test score. These differences usually are not aware of undergraduate researchers if  $c$ -scores which calculated using Eq. (2d) only within the interval 0 to  $-1$ , such as the student #2, #8 and #9. It is due to they understood that the maximum normalized loss should be  $-1$ . Undergraduate researchers

might then be aware their mistake when they encounter a case of student #6, #10 and #11, that instead indicates a positive normalized change greater than 1. For example, student #6 with the pre-test score is  $-4.0$  (30%) and the post-test score is  $-19.0$  (15%) if calculated using Eq. (2d), it yields results of  $+3.75$  and yields  $-0.48$  using Eq. (4b). It certainly would give significantly different average normalized change  $c_{ave}$ , causing misinterpretation of the results.

Table 1 also demonstrates a fairly small difference between  $\langle c \rangle$  and  $c_{ave}$  calculated using Eq. (4). The difference between these two scores ranges at 5% for sample  $N \geq 20$  (see footnote #46 in Hake, 1998). It indicates that the average single-student normalized change can also be an alternative to class-average normalized change. Marx and Cummings (2007) suggested the average single-student normalized change as a more effective way to characterize the whole class improvement and reveal how a group of students has changed after instruction (Bao, 2006). Finally, a suggested way to present a group’s improvement is to use the average single-student normalized change associated with the standard error of the mean  $sem_c$ , calculated by the formula . Thus, the group’s improvement of the illustrative example can be written as  $c_{ave} = 0.14 \pm 0.16$ . The  $c$ -score can also be written in the form of 0-100 interval as  $14 \pm 16$  (Cheng et al., 2004), which sometimes it is needed to represent data in a comparison graph effectively. This form often becomes one of the questions asked by the undergraduate students in the educational research methodology.

**Frequently Asked Questions**

The most frequent question arises in undergraduate research is about the divisions of  $c$ -score, comparison of the average  $c$ -score between two different groups, and another use of  $c$ -score.

**Shifting the divisionsc-scores**

There is a persistent belief in the undergraduate research that the division of ‘Hake gain’ (Hake, 1998) might not be shifted. Marx argues that depending on the test format, content area, assessment goals, and the specific sub-population, the divisions may shift<sup>1</sup>. Sometimes the divisions characterize definable shifts in understanding based on the test. Other times, though, the divisions may be more arbitrary and only used as a means to succinctly communicate broad findings. If we decide to shift these divisions, we should clearly define what these divisions represent and find reasons why we use other cut-off levels.

In the case of the Cornell Critical Thinking



**Table 1.** An illustrative example of fifteen pre-test and post-test scores and corresponding values of  $c$  calculated using Eq. (2) and Eq. (4) for each student, as well as the corresponding group average normalized change  $\langle c \rangle$ , the average of individual  $c$  ( $c_{ave}$ ), standard deviation and standard error of the mean for individual  $c$ 's.

Student	Pre-test raw score	Post-test raw score	$c$ calculated using	
			Eq. (4a, 2d)*	Eq. (4)
1	71.0	71.0		
2	71.0	60.5	-0.15	-0.10
3	50.0	60.5	0.50	0.50
4	50.0	71.0	1.00	1.00
5	12.5	12.5	0.00	0.00
6	-4.0	-19.0	3.75	-0.48
7	33.5	54.5	0.56	0.56
8	39.5	33.5	-0.15	-0.08
9	44.0	23.0	-0.48	-0.26
10	-10.0	-35.5	2.55	-1.00
11	-14.5	-25.0	0.72	-0.50
12	39.5	60.5	0.67	0.67
13	33.5	66.5	0.88	0.88
14	-14.5	39.5	0.63	0.63
15	-35.5	-35.5		
Averages	24.40	29.20	0.81	0.14
$\langle c \rangle$ Eq. (4a)		0.10		
Standard deviation of the mean ()			1.16	0.61
Standard error of the mean ()			0.30	0.16

\*Eq. (4a) for the gain and Eq. (2d) for the loss

Test, it doesn't have the divisions of  $c$ -scores to characterize the student's critical thinking improvement. Hence, it is free to make our own based on some external criteria. To set divisions, we need first to establish what the divisions mean and how we would measure them independent of the test. It is free to make the argument as to where the divisions are if we have evidence to affirm that our choices divide the test population in some meaningful way. One way to do that is base it on an analysis that compares test scores with some other measure, say interviews<sup>1</sup>. In other words, we try to ascertain that students who get a score above  $X$  have a reasonably good understanding of concept  $Y$ .

For example, the divisions of  $c$ -score by Hake (1998) demonstrates the improvement category of students' conceptual understanding as an impact of the active learning (in Hakes's case is Interactive Engagement) that promotes conceptual understanding and problem-solving. Therefore, it would be inappropriate to adopt Hake's

category into the increased critical thinking skills. Also, the divisions of  $c$ -score depend on the characteristic of the instrument and the populations where the instrument was measured.

#### Comparing two $c$ -scores

Undergraduate researchers usually use mean difference test ( $t$ -test) to infer the difference between  $c_{ave}$  of two groups, but the difficulty then arises the distribution of the values of  $c$  not always approximate a normal distribution. One potential way to solve this issue and compare  $c$ -scores between groups exposed to different pedagogies is to look at the standard error of the mean (Marx and Cummings, 2007). A slightly more sophisticated approach would be to calculate the standard error for the scores above the mean and then repeat for the scores below the mean. It would help highlight the possible non-normal distribution of  $c$ -scores<sup>1</sup>.

In details, when one calculates the standard error, there is a very basic formula that

incorporates the entire data set. So, out of that calculation, it gets one number, the standard error (SE) which is reported as  $MEAN \pm SE$ . The assumption being that numbers that are used to calculate the SE are normal about the mean. However,  $c$ -scores are typically not normal about the mean. As such, we used to calculate the SE only using the numbers above the mean (call it "SE+") and then do the second calculation with the numbers below the mean (call it "SE-"). Thus, we could report the mean as  $MEAN(+SE+, -SE-)$ . Once we have that mean with a range denoted by the upper and lower limits provided by  $MEAN+SE+$  and  $MEAN-SE-$ , we could compare that range to the range from other classes. If the range of standard errors for two set of courses does not overlap, one could claim that as evidence that, subject to the limitation of the survey instrument, the two courses have different degrees of learning. For example, if two courses had  $c$ -scores  $72 \pm 5$  and  $60 \pm 10$ , it would say there is no evidence that the instrument measured difference between those two populations.

However, one should be considered in the use of  $c$ -score is the issues of Performance Ceiling Effects (PCE) and a correlation between single-student  $c$  and the pre-test score (Hake, 1998). The researchers tend to accept  $c$ -score without worrying about this issues from because it is assumed they are not large effects<sup>1</sup>. We should always check to make sure that ceiling effects or strong correlations are not heavily influencing the analysis.

#### Another use of normalized loss

The normalized loss means negative normalized change. Regardless the use of  $c$  for the CCTT and based on the normalized change rationale, it can also be used to measure the effectiveness of an instruction to reduce misconception or a remedial instruction (Sriyansyah, 2015). Many previous types of research struggle to identify the students who hold misconceptions (Wijaya et al., 2016; Widarti et al., 2016), then reduce or remediate those misconceptions (Taufiq, 2012). The  $c$ -score formula, particularly Eq. (4b), has a great chance to be applied in such study to calculate the decreased number of students who hold misconceptions after instruction. This claim under rationale, i.e. the number of students who have been reduced or remediate divided by the total number of students that could have been reduced or remediate (the total number of students who hold a misconception at the beginning of the instruction).

## CONCLUSION

We have revealed the mistakes made by undergraduate researchers when applying the normalized change in the CCTT raw scores, as well as suggesting a modified equation that eliminates normalized loss bias and shapes a symmetric range of  $c$ -scores. We have also discussed some frequently asked questions by the undergraduate educational researcher. We hope this paper help undergraduate researchers understand well the normalized change to avoid misinterpretation of the data, particularly when applying the normalized change in case of the Cornell Critical Thinking Test or the test which has interval score from the non-zero minimum score to the certain maximum score. It would also make a researcher or an educator to reconsider and involve the performance of the students who get 'losses' into data analysis to clearly infer the effectiveness of the different learning pedagogies.

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**UNDERGRADUATE STUDENTS' MENTAL MODEL OF CELL BIOLOGY****S. Saptono\*, W. Isnaeni, S. Sukaesih**

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A descriptive study of future teacher students' mental models of essential concepts in Cell Biology was carried out through explanatory mixed-methods. Some students (n=40) of Biology Education Universitas Negeri Semarang were involved as the research subject. We used a diagnostic test, structured interview guides, and field notes to describe students' mental model. In the early stage, we prepare a diagnostic test performed essential concepts of Cell Biology. Secondly, we define students' mental models map based on their answers. Thirdly, we identify factors which affect students' mental models. Exploration of mental models was conducted through structured interviews with students representing each category. The interview focused on reasoning and argumentation students' abilities in answering the question on the test item. The research finding describes that students' mental model in Cell Biology is grouped into three categories, macro-mental to think based of basic content, micro-mental in correlation of content, and intuitive-mental or misconception. This finding can be used in improving research-based learning in Cell Biology.

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**Keywords:** cell biology; mental model; undergraduate students**INTRODUCTION**

One aspect was the focus of many research studies in science education is reform of science teaching as a learning process of science content and science learning as training and retention process of science content. This idea suggests that science learning process should pay more attention to students understanding science content. In this regard, explicitly American Association for the Advancement of Science/AAAS (2009) suggested that science learning should prioritize teaching for understanding.

Indicator of teaching for understanding successfully is students' ability in a wide range of thinking and reasoning, like how to explain, collecting evidence, providing an example, analyzing, making analogy and reasoning, and app-

lying scientific concepts in new situations (Greca & Moreira, 2000; Janssen, et al. 2009; Fry & Marshall, 2008; Johnson-Laird, 2010; Macbeth, et al., 2014). As an implication, the learning process in higher education should switch to higher order learning scheme (Fry & Marshall, 2008, Khasanah, et al., 2016). Higher order learning emphasizes on students understanding and creativity, such as being able to comprehend and construct knowledge based on facts, analyze the connection between knowledge with other relevant knowledge.

Learning in science has a very important role in concepts understanding, application of concepts, analytical thinking, and develop students' insights about daily life phenomena. The process of phenomena understanding in science has a positive contribution to reasoning ability development. Science learning process in college cannot be reached only by rote information, but it must be supported by logical reasoning and ana-

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lytical thinking.

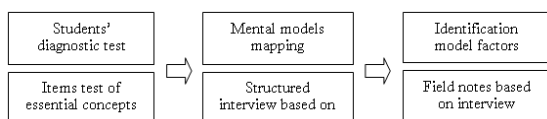
Study result (Fisher, et al., 2011) indicated that although students understand about the definition of diffusion and osmosis when students were given problems related diffusion and osmosis phenomena, it was found that most participants are not able to respond appropriately. Another study (Strickland, et al., 2010) describe differences of understanding among students after they learn about acids and bases. Wilson, et al.(2006) found that most biology students are not able to provide a comprehensive argument why someone is weight loss on a diet, although students have been learning about respiration and metabolism. More students memorize chemical reactions in cells only rather than trying to find factors caused chemical reactions can take place.

A variety of students' ability to interpret essential science concepts is a serious problem. Learning science should be planned more than studying textbooks and listen to information, but must provide the opportunity for students to develop critical thinking skills to understand natural phenomena (Lynd-Balta 2006; Fencil, 2010). By providing the opportunity for the student to understand science phenomena, they will be able to process, assemble, and represents science precisely. This study reported the description of the student teachers mental model in Cell Biology essential concepts.

## METHODS

The subject of this study was forty student teachers (n=40) of Biology Education Department, Universitas Negeri Semarang who have taken Cell Biology course.

The design of the study is explanatory mixed-methods. The study was implemented in three steps. In first, we gave a diagnostic test performed essential concepts of Cell Biology. Secondly, we define students' mental models map based on their answers. Thirdly, we identify factors which affect students' mental models. Exploration of mental models was conducted through structured interviews. We interviewed students representing specific answers. Figure 1 as below shows the research method.



**Figure 1.** Research method

Diagnostic test as an instrument consists

of 9 test items argumentative multiple choice. Students should give an argument for each test item answer. The diagnostic test includes essential concepts of the Plasma Membrane and Organelle Producing Energy. The essential concept is divided into three categories, i.e. basic concepts, application of concepts, and relationships between concepts. The diagnostic test was given after learning process.

Data of diagnostic test results were analyzed based on student answers. The qualitative descriptive technique was used to analyze data. Data is described and categorized in two types of answers, correct answer and false answer.

Data from interviews and field notes were analyzed qualitatively, by tracing and identify "why the student is answering like that"? The results of the interview were used to classify students' mental model.

## RESULTS AND DISCUSSION

### Basic Concepts

Question 1:

The plasma membrane found in prokaryotes and eukaryotes. In eukaryotic cells, where plasma membrane to be found? Table 1 shows the variation of student answers.

**Table 1.** Students' understanding of plasma membrane in eukaryotic cell

Category	Number of students	%
True answer:		
Vakuola, Golgi complex, lysosome	5	12.5
False answer:		
Mitochondrion, endoplasmic reticulum, ribosome	14	35
Nucleus, mitochondrion, microtubules	2	5
Chloroplast, centrosome, endoplasmic reticulum	8	20
Golgi complex, ribosome, nucleus	11	27.5
Number of students	40	100

Question 2:

What causes simple diffusion can occur?

Variation of student answers can be seen in Table 2.

**Table 2.** Distribution of students' understanding of simple diffusion

Category	Number of students	%
True answer:		
There are porous in fat layers	27	67.5
False answer:		
Protein helps diffusion membrane	7	17.5
The fat layer is permeable	0	5
Water can bind to protein	0	20
Higher concentration of intracellular fluid	6	15
Number of students	40	100

**Question 3:**

If we consume foods containing glucose, how can glucose contribute to the movements?

Table 3 shows the variation of student answers.

**Table 3.** Students' understanding of glucose role in energy producing

Category	Number of Students	%
True answer:		
Chemical potential energy of glucose changed into CO <sub>2</sub>	9	22.5
False answer:		
Glucose molecule transformed into energy and O <sub>2</sub>	8	20
Glucose molecules react with ATP to form energy	17	42.5
Glucose molecule change ATP into energy and H <sub>2</sub> O	3	7.5
Chemical potential energy of glucose changed into O <sub>2</sub>	3	7.5
Number of students	40	100

**Concepts Application****Question 4:**

A vessel is sealed with a semipermeable membrane (there is a picture). On side one filled water and concentrated dyes. The side two only contains water. The high surface of both sides is the same. After two hours, what will happen to the water in side1 and 2?

Variation of student answers has shown in Table 4.

**Table 4.** Students' understanding of semipermeable membrane

Category	Number of students	%
True answer:		
Water in side 2 will be higher than side 1	6	15
False answer:		
Water in side 1 will be higher than the 2	26	65
Height of both sides will remain the same	4	10
Water in side 1 will be higher and will return the same	2	5
Water in side 2 will be higher and will return the same	2	5
Number of students	40	100

**Question 5:**

Margarine is made from vegetable oils in solid form through a chemical process. What happens to the plant oils that initially a liquid can turn into a solid as in margarine?

Variations student answers can be seen in Table 5.

**Table 5.** Students' understanding of temperature effect on phospholipids

Category	Number of students	%
True answer:		
There were changes in phospholipids saturation	8	20
False answer:		
Doubling occurs on phospholipid structure	2	5
Reduction in lipids liquid content	9	22.5
Evaporation occurs in part of phospholipids	10	25
Reduction in phospholipid amount	11	27.5
Number of students	40	100

**Question 6:**

You had a friend who was doing a diet. After an interval time his fat mass down to 3 kg. Where is your friend fat loss? Answer students were shown in Table 6.

**Table 6.** Students' reasoning about reduction of fat in diet program

Category	Number of students	%
True answer: Release in the form of CO <sub>2</sub> dan H <sub>2</sub> O	5	12.5
False answer: Eliminated because of body heat	2	5
Tied proteins and form lipoproteins	8	20
Converted into fatty acids and released	17	42.5
Digested in stomach and released	8	20
Number of students	40	100

**Connection between Concepts**

## Question 7:

A plant is growing in a pot in the sun. If that plant is placed in a dark place for a few days (its water needs was maintained), what will occur with plant biomass?

Variation student answers can be seen in Table 7.

**Table 7.** Students' reasoning about role of biomass in respiration

Category	Number of students	%
True answer: Reduced, because respiration occurs even though in a dark place	2	5
False answer: Increases, because in a dark place plant will grow length-wise	24	60
Increases, because reaction occurs to produce glucose	8	20
Reduced, because water in plant will evaporate	1	2.5
Still, because in plant is not produce carbohydrates	5	12.5
Number of students	40	100

## Question 8:

There is a scheme of the relationship between respiration and photosynthesis. What

events are by the scheme?

Variations of student answers can be seen in Table 8.

**Table 8.** Students' perception related respiration and photosynthesis

Category	Number of students	%
True answer: Oxygen as a photosynthesis result takes to burn glucose in the mitochondria	15	37.5
False answer: CO <sub>2</sub> as respiration results needed in photosynthesis to burn glucose	10	25
CO <sub>2</sub> released from the chloroplasts through respiration	9	22.5
CO <sub>2</sub> is produced in photosynthesis metabolism	4	10
Oxygen and CO <sub>2</sub> are needed for respiration and photosynthesis	2	5
Number of students	40	100

## Question 9:

Research conducted to investigate the role of an organism cell organelles. Observation result related changes in solute substance as below.

Glucose	Unchanged
CO <sub>2</sub>	Increases
O <sub>2</sub>	Unchanged
ATP	Increases

Based on the finding, what metabolic processes these organelles play a role?

Variation of students' answer can be seen in Table 9.

**Table 9.** Students' conception in cellular respiration

Category	Number of students	%
True answer: Krebs cycle	13	32.5
False answer: Light reaction	7	17.5
Calvin cycle	5	12.5
Glycolysis	10	25
Oxidative phosphorylation	5	12.5
Number of students	40	100

Future teacher students' misconceptions were found is a representation of ability to grasp and understand essential concepts of cell biology. Diagnostic test results represent several categories of misconceptions possessed by students. Variations in student answers may be caused by limitations of different capabilities, in addition to a different learning experience as well. Besnard, et al. (2004) argues that the dynamic mental system strongly influences the comprehension ability as critical for responding to stimuli coming.

The results of the interview can provide a more realistic description of students understanding differences. Interview conducted on several students who purposively selected because they relate to the characteristics of student answers. Here are excerpts of interview results. It was performed to identify misconceptions students through question number 1 on cell biology basic concepts.

Lecturer: "What's your answer for number 1 question?"

Student 1: "I answered that plasma membrane of mitochondria, endoplasmic reticulum, and the ribosome."

Lecturer: "Why?"

Student 1: "Because of plasma membrane found in mitochondria, ER, and the ribosome."

Lecturer: "What about your answer (student 2)?"

Student 2: "I answered on Golgi complex, ribosomes, and nucleus."

Lecturer: "Actually, what is ribosome? Is it one of cell organelles?"

Students 1,2: (speechless and thinking)

Lecturer: "What about your answer (3 students)?"

Student 3: "I think the answer is chloroplast, centrosome, and ER."

Lecturer: "According to you, what is centrosome? Do centrosome surrounded by a plasma membrane?"

Student 3: (speechless).

Based on the interview we can identify one of the mental models of students, such as students tend to use intuition to make decisions in answering test questions. Students are not able to give the right arguments about ribosome and centrosome structure but still choose the incorrect answer. The results of the interview also provide information that we found students who do not understand the basic concepts even though they have learned for one semester. It has also been identified in some items about basic concepts, such as questions number 2, 3, and 4.

Students fail to understand their experiences caused essential concept. Lack of ability to

understand main text ideas and less of using reasoning abilities were main factors in the construction of intuitive mental models. Construct a mental error model of specific content is caused by a partial representation and limited scope of phenomena understanding, and it will be a misconception (Besnard, et al., 2004; Strickland, et al., 2010; Wijaya, et al., 2016).

Another finding from interview provides information that we found students' misconceptions. Students can understand the basic concepts, but they are not able to apply concepts they have been mastered. Most students fail to apply concept on other conditions. Here are interview excerpts to question number 7.

Lecturer: "What is your answer about the role of biomass in respiration?"

Student 4: "I chose, it will grow because of etiolation process."

Student 5: "I also said to be generated increased because of the starch."

Student 6: "I answered not increasing and not decreasing."

Lecturer: "Please, try to be rethought, in dark conditions without light, plants perform respiration or not? If you do respiration, what does it mean?"

Student 4,5,6: "There was demolition biomass."

Those interview results indicated that students could find events of photosynthesis and respiration in plants. However, not all students can apply their understanding phenomenon represented. Student 4 has understood about etiolation phenomenon can occur in dark conditions, but she is not able to apply respiration process was occurs. Five students failed to understand that photosynthesis requires light energy. Six students understand the phenomenon of light energy needed for photosynthesis, but they are not able to apply that respiration is also performed in dark conditions.

Based on question number 5, 6, 7 and 8 on exposure results, it can be identified by students' misconceptions. They are only able to recognize the concept of the content, but they are not able to apply it. Respectively, based on their answers to questions describe that students are not able to apply the concept of respiration and photosynthesis in certain conditions.

The ability of concept application requires higher order thinking, like reasoning and to think systemically. Assaraf & Orion (2005) asserts that development of systemic thinking is needed to support high-level capabilities, such as applying, analyzing, and arguing. It implies the importance of exercise to develop the ability to think at the



high level for students to understand and be able to apply concepts they have learned.

The result of the interview focused on identification of other misconceptions. There is one category provides information that students have understood the basic concepts, but they are not able to associate the concept with other relevant concepts. Nonetheless, we found some students who successfully managed an understanding associated with essential concepts of cell biology. Here are excerpts of the interview to question number 9.

Lecturer: "How do you answer the question number 9?"

Students 7: "The oxygen of photosynthesis takes to burn glucose in mitochondria."

Students 8: "The same answer."

Lecturer: "Give me an argument for your answer?"

Students 8: "Diagram shows that there is a relationship between photosynthesis and cellular respiration processes. In photosynthesis generated oxygen which can be used for formation of energy through respiration".

Students 7: "The same answer, Sir. In photosynthesis generated oxygen. Oxygen can be used in cellular respiration process".

Micro mental model students are also identified through question number 10, which is to question the relationship between glycolysis, Krebs cycle, and oxidative phosphorylation in cellular respiration, as well as the light reactions and the Calvin cycle in photosynthesis. Students can construct understanding relationships precisely.

The phenomenon of this study provides information; student teachers misconceptions are affected by experience and ability. Student misconceptions can be divided into three categories: basic concepts, application of concepts, and relationships between concepts. The understanding can be reconstructed through a cognitive conflict in the learning process. Duit & Treagust (2003) provides an alternative model of conceptual change to reconstruct understanding. Conceptual change model allows students perform cognitive conflict. Furthermore, students can reconstruct their understanding.

The results of diagnostic tests on basic concept show that most students can understand plasma membrane concept and provide the right answers. However, some other still have difficulty to understand the concept of plasma membrane existence. As in Question 1, we found only 12.5

% of students who answered correctly, and the others have misconceptions. Students' argumentation by interview describes that there are students who understand that ribosome is an organelle with a membrane. There are also students who thought that microtubules have a membrane, and vacuole did not have a membrane.

The same thing happened to simple diffusion concept across of plasma membrane. We found that 67.5 % of students can understand diffusion concept. However, we found students have the perception that simple diffusion across of membrane occurs caused by protein assistance or higher concentration of cell fluid. In the interview process, we found that student misconceptions were caused by fail students' perceptions of simple diffusion concept. Perception of students was troubled by different of processes in simple diffusion, facilitated diffusion, and osmosis.

Another finding shows that only 22.5 % of students can understand the concept of energy producing. Students are confident that energy producing occurs in respiration metabolism. Most of the other students have varying perceptions. We found students who think right that glucose molecule is converted into energy and  $O_2$ . But, we found another false answer that glucose molecules will react with ATP to form energy, glucose molecules transform ATP into energy and  $H_2O$ , and the potential energy of glucose will be changed into  $O_2$ .

Based on these findings we can take a premise that mental models of students about basic concepts of Cell Biology can be divided into two categories, i.e. students who have capabilities on basic concepts, and students who have misconceptions about basic concepts. Data show that we still found students who have not been able to understand basic concepts well.

The results of diagnostic tests on applying concept suggest that there are students who master on basic concepts and be able to apply concepts in new situations. Nonetheless, we found that students master on basic concepts but are not able to apply the concept in other situations. Only 15 % of students can master basic concepts and apply concepts in the problem of Question 4. They cannot apply their osmosis concept across of plasma membrane on a diagram or picture. When we asked about osmosis definition, students were able to answer correctly. But, when we asked the question on diagrams or pictures, students fail to apply the concept.

In Question 6, we asked about concept application of cellular respiration which occurs in the diet program. Only 12.5 % of students can

apply respiration concept. The other 77.5 % of students failed to apply respiration concept in the diet program. Interview results indicated that students who fail to apply the concept, they understand that respiration in mitochondria releases  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . However, they fail when we faced them with dietary issues related to cellular respiration concept.

Based on diagnostic tests results of concept application, we identified three categories of student mental models. First, the macro mental model represents the ability of basic concepts. Second, the micro mental model represents the ability to apply the concept. Third, intuitive or misconceptions mental model represents of inability to apply the concept.

Results of diagnostic tests of student ability to relate to concepts, we got information that there are students who appropriately able to associate with concepts. However, only 37.5% of students have exactly ability to connect respiration and photosynthesis concept in Question 8. The other students have varying abilities. Argumentation interviews described that students could understand respiration and photosynthesis concept, but they failed in linking these concepts. There are also student misconceptions about these concepts. Our data obtained, the same thing happened to Question 9.

We have identified kind of mental models about student ability to connect between concepts. There are three kinds of student mental models. First, the macro mental model represents of student mastery of basic concepts. Second, the micro mental model represents of student capabilities of concepts link, and intuitive or misconceptions as representing the failure of students understand.

A mental model is an internal representation of object, idea or process that allows cognitive abilities give a reason, an explanation, or predict phenomena for problem resolution (Janssen, et al., 2009; Wang & Borrow, 2011; Jansoon, et al., 2009; Johnson-Laird, 2013). A mental model is expressed through individual interpretation. Interpretation can be based on interactions with the environment, individual memory, learning outcomes of individual diagrams, or information on the article.

Lecturers or teachers should be paying attention to students' mental model before they give opportunities their students learn more. Some research results indicated that implementation of science learning in higher education is more concerned about comprehensive content (Wilson, et al., 2006; Bao, et al., 2009; Jansoon, et al., 2009).

Fencl(2010) describes that teachers of colleges tend to provide extensive material to students in learning. The breadth of science content is required in science learning to understand natural phenomena, but these conditions are not enough to ensure that students will understand the entire content. Higher thinking should be a crucial goal in science. Some researchers assumed that conditional reasoning is a critical component of logical and deductive thinking that teachers could improve it in the learning process so that students could make some inferences (Markovits&Barrouillet, 2002; García-Madruga, et al., 2002; Santamaría et al., 2013). For meaningful learning, teachers may apply conceptual change scheme to improve students' mental model (Duit&Treagust, 2003; Michael, 2004, Mohammed, et al., 2010; Hegarty, et al., 2013; Albaiti, et al., 2016).

## CONCLUSION

Student teachers' mental model about Cell Biology essential concepts can be divided into three categories. First, macro-mental models that represent students are only able to understand basic concepts but are not able to associate with concepts. Second, micro-mental models that represent students can understand basic concepts and connect between concepts. Third, intuitive-mental models or misconceptions that represent students are not able to understand basic concepts.

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## META-ANALYSIS OF JELAJAH ALAM SEKITAR (JAS) APPROACH IMPLEMENTATION IN LEARNING PROCESS

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### ABSTRACT

The results of tracer studies on the approach of Jelajah Alam Sekitar (JAS) or environment exploring learning has been detected is used in eight provinces in Indonesia and studied in the learning begin primary school to college. Then, how the effectiveness of the implementation of the JAS approach in improving the learning process. This study uses meta-analysis-data in the form of descriptive exploratory qualitative. Data was taken from the various thesis, and research faculty in the last 10 years. Data analysis was performed by calculating the percentage of the same findings for similar problems. The results showed a wide range of studies using different methods and approach such as qualitative descriptive, quasi-experimental, PTK and R and D to produce evidence that the approach JAS effective when applied in teaching, especially teaching biology in a variety of teaching materials. Various studies have shown the approach JAS managed to increase learning outcomes, can differentiate learning outcomes between treatment and control groups in which the treatment group had a mean score higher. Models/strategies/methods centered learning students are very relevant to implementation approach JAS making it seem more real, like a model of cooperative learning, think pair share, strategy role-playing, the investigation group, learning cycle 5e, hands-on activity, and so on, making it possible to continuously assessed and developed in the paradigm of competency-based curriculum developed.

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**Keywords:** JAS; environment exploring learning approach; learning process; meta-analyses

### INTRODUCTION

Biology as a science is different with another science knowledge. The uniqueness of biology is that the objects are living creature. Thus, it can be concluded that biology has its characteristics. Biology as a part of science pointing in giving direct experience to develop the competence so the students can explore the nature scientifically, a kind of learning that combine science process experience and science product understanding.

Biology Department of FMIPA UNNES has developed Jelajah Alam Sekitar (JAS) Learning Approach since 2005. Ridlo (2005) have

done tracer towards JAS implementation, which shows since 2006 to 2016, JAS has been spread in eight provinces in Indonesia although most of it are in Central Java especially in Semarang. JAS has been researched to be used in the learning process from elementary school to university. JAS approach also tracked as the most examined using quantitative research with pre and quasi-experiment design. After that, the tracer will be interesting if a meta-analysis is done to know the effectiveness of JAS usage in the learning process.

JAS learning approach can be defined as an approach that uses the student's nature environment, whether the physical, social, technology, or culture environment as the learning object in biology whose phenomena can be learned

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through scientific work (Marianti & Kartijono 2005). Learning by using JAS approach can use the environment to outdoor learning, and the effects of environment care behavior have been conducted by Amini (2015). The result of the research shows that classical completeness is getting better and the nature care behavior is in an excellent category.

The result of tracer study either documentary or online by Ridlo et al., (2016), JAS approach has been implemented in a few lessons in Indonesia. A brief description of the result of JAS implementation research from 2005 to 2016 will be explained below.

The research of JAS approach implementation in many subjects has been done. Riyanto, et al. (2005) have implementing JAS approach in Micro Teaching subject. The result shows that the increase of the variation of approaches, strategies, and learning methods that being chosen by the students in conducting Learning Plan. Micro Teaching practice also held in outdoor instead of indoor only by using the environment as the learning source.

JAS approach implementation combined with role playing method in ecosystem subject in Pondok Pesantren Modern Selamat Kendal (Ngabekti et.al., 2015). This research began with the problem of most students being sleepy in almost every subject. The activities in the Islamic boarding school that began from 04.00-21.00 is the main cause of this problem. With JAS approach implementation that combined with role playing method, there is no more sleepy student in class. The usage of the boarding school's environment as the learning source in JAS approach also increase the activity and learning result of the students.

JAS approach implementation in a Biostatic subject has been done by Budiyanto & Ngabekti (2007). The result of the research shows the increase of motivation and learning result. Around 78% of the students get their score in B, AB, and A category while the rest are C and BC. According to the researches above, it can be stated that JAS approach with its six characteristics affecting the activity, motivation, and the result positively.

Sugiyo, et al.,(2008). Team Game Tournament (TGT) learning model by using Jelajah Alam Sekitar (JAS) approach accompanied with Portfolio scoring in Koloid System main discussion can increase the study result of the eleventh-grade students in their second semester in MA Al-Asror Semarang with the percentage of completeness of 97,37%. The average score

for the students psychomotor is taken from the demonstration score that has been done by the students, which is 71.58; while the average score of student's discussion is 76.20. The activity of the students increased because of the treatment (demonstration, discussion, and tournament). The percentage of the activity of the students in the first cycle is 70.13%, in the second cycle is 72.70% and in the third cycle is 75.20%. These means the students are getting more active and happy to learn chemistry.

Auliaty, (2015), in the research that uses a grass field as the learning source in living creature component and environment subject by implementing Group Investigation learning model and Jelajah Alam Sekitar (JAS) approach in SDN Pulogebang 08 Pagi, can increase the student's study completeness. Sari, et al. (2012) stated that the usage of education tour garden of UNNES as the learning source in living creature classification subject by implementing JAS approach could optimize the activity and the study result of the students of SMP Teuku Umar.

Widana (2014) reported that the implementation of JAS approach to the seventh-grade students in SMP Banyuglugur could increase the classical completeness from 78.78% to 100%. Fadllia (2012) get the result that study journal making in JAS approach affected the student's study result in Ecosystem material in SMA Negeri 1 Kaliwungu, whether in cognitive, affective, or psychomotor. The result of the analysis of t-test statistic achieved the sig score = 0.005 < 0.05. It means there is a difference in the cognitive score between the experiment and control class.

Wahyuni (2012) came to a conclusion that learning implementation in digestive system material with JAS approach affected positively towards mastering the science process skill of the students in SMAN 12 Semarang. The result of biserial correlation test analysis shows the coefficient of biserial correlation  $r_b$  as many as 0.31 and the determination coefficient as many as 10%. Significance test result of  $r_b$  calculated by t-test, resulting in t count > t table which is 4.68 > 1.993. The percentage of the study result in experiment class > study result of control class (100% > 57%). 97% of the students give very good responses and good toward the implementation of JAS approach in learning digestive system material towards mastering science process skill. The teacher gives a positive response towards the learning process.

The result of Student's Work Sheet with a Picture by (2012) shows that the study result of the students using Student's Work Sheet with a

picture with JAS approach is better than the students who used Student's Work Sheet with no picture without using JAS approach. Based on the recapitulation result of the activity of the students, it shows that the activity of the students in experiment class included in the very high category while the control class included in the middle category. Student's Work Sheet with a picture with JAS approach is suitable if implemented in environment organizing material.

The implementation of JAS approach in biotechnology material through the observation of soy sauce fermentation process in SMP Negeri 1 Blora has been done by Ristanti (2012). The result can optimize the activity and study result of the students. The average of student's activity along the learning process reached 92%. The classical completeness of the study result is 96%. From the observation of the soy sauce fermentation process, the students got the study experience so it can optimize the student's activity and study result.

JAS approach which accompanied by Problem Based Learning with The Environment as The Learning Source (Prमितasari, 2012) shows the study result of the students in experiment class is better than the control class. The analysis of student's activity observation result sheet shows the classical average score of experiment class is higher than control class.

The Effectiveness of Quantum Teaching Method Implementation in Conservation and Character Based JAS Approach also had been made by Sari (2012) in SMP N 1 Bae Kudus. The result of the student's activity analysis in experiment class is a higher classical average than the control class. The result of the character of the student's analysis which measured by behavior scale (Likert scale) is good. The result of the research can be concluded that the learning with Quantum Teaching Method in Conservation and Character Based JAS approach is effectively implemented towards the activity and study result and character building of the students.

The research of Indriasih (2013) resulted process skill in learning has a quite big impact towards the study result. Process skill towards the students in Science subject with JAS approach has a linear relation towards the student's study result. The amount of process skill in students in learning determination coefficient is 0.616. This result means the process skill affecting the study result as many as 61.6%; there are still outside effect as many as 38.4%. While Marianti et al. (2013) stated JAS approach with project-based learning can increase the student's score as many

as 70% in Animal Physiology subject to A, AB, and B without any D or E score.

Ridlo & Alimah, (2013) stated that biology learning with student centering approach that specialized in JAS activity could be done using active and cooperative student learning system strategy. Those strategies are contextual learning, participative learning, and inquiry learning. Meanwhile, in the same year, Winarni (2015) stated that the study result of environment care behavior, process skill, and concept understanding aspect in the group of students that follow the science learning with JAS approach are better than the student group with expository learning. Sari et al. (2013) who combine Quantum Teaching learning with conservation and character based JAS approach is effective to be implemented to optimize the activity and study result of the students. Besides, it also is an effective way to build the student's character in the learning process.

Alimah et al. (2014), stated that Meksint Korefsi Model with JAS approach in Animal Body Structure Learning is developed into three phases which are planning, design and developing and three times of evaluation which are alpha test, beta test, and field test, deserve to be used as an alternative model choice in Animal Body Structure learning. Alimah (2014) Experiential Jelajah Alam Sekitar (EJAS) Model can use the designing learning process to increase the student's critical thinking ability strategy. The implementation of EJAS in designing the learning activity in class whether indoor or outdoor can increase the ability of student's critical, rational thinking in learning biology.

Erwan & Achyani (2014) who researched the JAS approach learning implementation with experiment method can increase the understanding of tenth-grade students in SMA Muhammadiyah 2 Metro in 2011/2012. Meanwhile, Yunita, et al. (2014) stated that the implementation of Group Investigation method with Jas approach could optimize the activity and study result of the students in learning Life Continuance of Living Creature material in SMP Negeri 2 Brangsong. The contribution of JAS approach towards the students according to Hidayah (2014) is 41.3%.

Module development for digestive system material by Safarini (2014) shows that the scoring of module developing result pass the evaluation by the material expert, media expert, and JAS expert. Based on the trial of module usage shows that the study result of test class is higher than control class the test class is 90%, while the control class is 70%. The activity of the students shows that  $\geq 80\%$  of the students have the active

activity and very active level. The response of the students and the teacher towards the module are very good.

Fatimah (2015) has done the research on the class action to increase the critical thinking ability and creativity of the students in seventh grade through PBL implementation with JAS approach. The result shows that in the first cycle the learning with direct exploration caused the increase of the critical thinking ability by 74.35%. In the second cycle with indirect exploration, the creativity increased by 66.96%. This research concluded the PBL implementation with JAS approach is effective to fix the critical thinking ability and creativity of the students.

The result of a research by Pratama (2014) about the implementation JAS approach concluded: (1) development of JAS approach based module which integrated with Java culture in Earth and Moon Movement using 4D model which are definition, designing, development, and spreading, (2) the achievement of student's study result increased significantly in "Middle" category, (3) there are differences in the student's study result, before, and after the module being implemented, (4) the result of the teachers and students responses towards the learning module that being developed have a "Good" category. Meanwhile Palisoa & Wali (2010), tt. stated that JAS approach implementation resulting as many as 32 students (94,11%) had achieved their Minimum Passing Criteria.

Danis, et al. (2015), the result of their research conclude that the implementation of JAS approach resulting: 1) The average of absorption power in experiment class is 80% with good category while in control class is 74% with the good category. Based on the absorption power of the students it can be said the effectiveness of the learning in experiment class and control class are effective. 2) The study completeness of the students classically in experiment class is 84% while in control class is 62.5% stated incompletely. Classical completeness of process skill indicator in experiment class is 100% while the control class is 75%. Classical completeness of process skill indicator in experiment class is stated as complete while the control class is stated as incomplete.

The research of Ngabekti, et al. (2015) has implemented JAS approach in Animal Ecology subject. The result of the research concludes that by implementing JAS approach, the activity of exploration/discussion and the study result of the students in Animal Ecology subject are increased. The implementation of alternative as-

essment in JAS strategy in reproduction system material learning in senior high school which has been done by Widyastuti (2015) shows that the study result of the students in three scoring field have already fulfilled the criteria with  $\geq 75\%$  are above the determined Minimum Passing Criteria. Some students that pass the Minimum Passing Criteria in the cognitive field are 71 students, in the affective field are 68 students with good behavior while in the psychomotor field are 65 students.

Auliaty (2015) from her research conclude the study result of the students using JAS approach in ecosystem material learning in tenth grade giving a better study result in experiment class than the control class. Based on the result of recapitulation of the student's activity, it shows that the activity of the students in experiment class included in the very high category while the control class included in the middle category.

The result of the research conducted by Savitri & Sudarmin (2016) stated that the students in Integrated Science Department who attended Conservation and Local Wisdom in 2014/2015 could lead to a product from learning model with integrated JAS approach as an effort of accelerated visualization of the UNNES's vision and mission as a conservative university. Besides, the team of the lecturers in Conservation and Local Wisdom subject also capable of resulting an innovative conservation soft skill learning device with a valid JAS approach integrated with Conservation and Local Wisdom subject in Science Department in the form of learning device. The implementation of learning model with JAS approach integrated with Conservation and Local Wisdom subject in Science Department is effective in building the student's soft skill conservation behavior and action.

The result of the research of JAS approach implementation by Ardini, et al. (2016) stated, the average absorption power in experiment class is 78.4% with good category while in control class is 74.79% with the good category. Based on the absorption power of the students, it can be said that the learning in experiment and control class are effective. The study completeness of the students classically in experiment class is 88% stated as complete and in control class is 87.5% stated as complete. The completeness of competence achievement indicator in experiment class is 75%, and in control, class is 75%. Overall, the completeness of competence achievement indicator both in experiment and control class are stated as complete.

Implementation of JAS approach by Using



Biology Laboratory and UNNES's Educational Tour Garden as The Study Source of Biological Diversity Material had been done by Alvitarsi (2016). Based on the psychomotor and affective aspect data analysis, experiment class gets a better result than the control class, which is 100% of the students included in A category. In the affective aspect in experiment class, 85.7% of the students are included in the very good category, and the rest are included in the good category. 98.9% of the learning process is well done. 98.3% of the responses of the students agrees with the JAS approach, while the teachers also give positive responses towards the learning process.

Based on the researches above, it is important to do a meta-analysis. Meta-analysis can be simply meant as the analysis of analysis (Merriyana, 2006). Meta-analysis is a study of some researches with a common problem and a way to make a summary of the result of a research quantitatively. Meta-analysis is used to organize and dig the information as many as possible from the given data. One of the requirements that are needed in doing meta-analysis is a study towards the results of a kind of researches. The result of the primer study analysis is used as a base to accept or support the hypothesis, reject/abort the hypothesis submitted by some researchers. Meta-analysis is used to look for the significance of treatment towards the students. For example, the effects of learning model toward student's study result and motivation. The meta-analysis also can be used for research designed not with an experiment design, like descriptive research.

## METHODS

Problems or topics that will be researched have been determined to be known whether JAS approach implementation affected effectively towards student's study result. For that, the period of the research results that being used as the data source are the last 10 years from 2006 to 2016. The data gathering technique, including survey, documentation, and questionnaire. The survey was done in High School Library online. The report of the research that related to the research problems are in the form of essay, thesis, dissertation, or another report that can be collected from the library of UNNES, UPGRIS, and the internet. As many as 106 research titles have been analyzed for the suitability towards the problem that being researched. The research focused on the research methodology (type, place and time, method), and the result. The approach that been used is qualitative research in the form of desc-

riptive explorative with critical analysis. The utilization of questionnaire through postal items and electronic were sent to the addresses of the working/domiciled alumni. All data that have been gathered through the survey, questionnaire or documentation are analyzed by using descriptive analysis technique. To know the conclusion of the qualitative research, the percentage calculation of the same findings was done for the same problem.

## RESULT AND DISCUSSION

### The result of Meta-analysis of JAS approach implementation

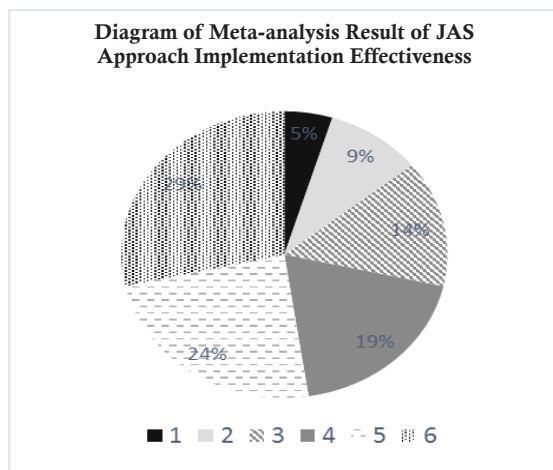
Below are the results of meta-analysis toward JAS approach implementation. The effective construct is coded into 6 indicators. The result of the meta-analysis towards the result of earlier research analysis is shown in Table 1.

**Table 1.** The result of Meta-analysis towards Effectiveness Construct of JAS Approach Implementation

Result of Implementation	Code	Number	Percentage (n=103)
Optimizing Activity	1	43	40,57
Optimizing study result	2	56	52,83
Optimizing skill (science process)	3	7	6,60
Effective to be used in learning	4	39	36,79
Minimum Passing Criteria classically not achieved	5	1	0,94
Have not achieved base competence maximally	6	2	1,89

The effectiveness of JAS approach has been proved by 52.83% of researchers, with optimizing the study result indicator that been proved by the average result of group test achievement of the students with JAS approach are better, complete, or increased. JAS implementation also can optimize the study activity (40.57%). The meta-analysis result also shows effectiveness without detailing what is meant by effective as many as 36.79%. Overall, the meta-analysis result shows the effectiveness of JAS approach as many as 97%.





**Figure 1.** Shows a circle diagram of meta-analysis result of JAS approach effectiveness percentage.

### The Result of JAS Approach Implementation in Learning Process Questionnaire Analysis.

Respondent's personal data can be seen in Table 2.

**Table 2.** Respondent's Personal Data

Question	Answer	Percentage
Gender	Male	23%
	Female	77%
Status	Married	69%
	Unmarried	23%
Last Education	S1	15%
	S2	31%
	S3	46%
	S3	46%

The meta-analysis result of JAS approach in learning questionnaire, the data were gotten are shown in Table 3.

Table 3 shows part of the JAS approach learning users sure that they have been using it, but the other part unsure whether they have used it properly or not. Most of JAS users stated that they had not done the alternative assessment when using JAS approach. Entertaining learning

**Table 3.** JAS Approach Implementation in Learning Process

Question	Answer	Percentage
JAS approach implementation correspond to the characteristic	Yes	54%
	Not Fully Yet	46%
The characteristic that can not be done yet is ...	(1) constructivism	38%
	(2) science process	31%
	(3) inquiry	31%
	(4) exploration of surrounding nature	38%
	(5) bioedutainment	46%
	(6) alternative assessment	54%
The reason of the undone characteristic	Hard to catch the means	8%
	Too much/too many characteristics	15%
	Not every characteristic must be done	54%
	No indicator in every characteristic	31%
	Other	
Repetition frequent of JAS approach implementation for research purposes	There is an unentertain material	8%
	Yes 2/3 Times	31%
	Not Yet	38%
Aim of JAS approach implementation in learning process	There is a plan to do it again	46%
	Common Learning	77%
	Research	54%
	Thesis Conductance (S2)	0%
	Dissertation Conductance	8%

(edutainment) is still rarely happened. However, most of them reasoned that it is not that they do not understand about JAS but because not every characteristic of JAS should be in the learning process. But still, the research that includes Taufik et al., (2014) has done edutainment component by inserting puzzle game, crossword, and square word with Technology of Information and Communication basis. The result of the research shows a study result gain as many as 0.85 included in high category and environment care behavior as many as 93.75% included in the culture category.

To erase all the doubts, JAS users stated their plan to do the research again. The thing that the Biology Department must appreciate is that JAS approach is not only used when there is research being conducted but also has been implemented in daily learning. JAS implementation is not free from problem and benefits, but the researcher also gives suggestions and benefits of JAS approach as shown in Table 4.

Based on Table 4 it is outlined the following things. JAS approach is effective to fix the learning process and study result and commonly stated as satisfying. The users of JAS approach are agreed that the main benefit of JAS approach is contextual and factual, fulfilling PAKEM

learning requirements, and suited to learning models that have been recommended by Curriculum 2013 in elementary and middle schools. However, the users usually have some difficulties in allocating time and need more powers when applying this approach. The efforts that have been done to overcome the problems are asking the observer in exploration activity, increasing time allocation outside the determined hour, and applying self-assessment. Those findings should push Biology Department of UNNES to keep analyzing the benefits and weaknesses to conduct a guide of JAS approach implementation.

The push towards the department is not without reasons. First, some users who stated that the very high suitability of knowledge and skill would be achieved when JAS approach is being implemented. Second, information about JAS approach is still rare to be found in printed and electronic media. Third, the user's scoring toward the level of meaning that collected by implementing JAS studied from many aspects is not so high, only in a level of quite meaningful. Therefore, the users suggested that the academicians of Biology Department of UNNES committed to keep observing and publish the result in reputable journals.

**Table 4.** Effectiveness, Satisfaction, Benefits, Problem, Suggestion, and Benefit of JAS Approach Implementation in Learning Process

No	Question	Answer	Percentage
1	Effectiveness of JAS approach to fixing the learning process	Very Effective	31%
		Effective	54%
2	Effectiveness of JAS approach to fixing the study result	Very Effective	15%
		Effective	54%
3	Satisfaction level towards the implementation of JAS approach in learning process	Very Satisfied	15%
		Satisfied	62%
4	Satisfaction level towards the result of implementation of JAS approach in learning process	Very Satisfied	23%
		Satisfied	38%
5	Benefits from JAS approach	Very suitable with learning model which suggested by curriculum 13	54%
		Contextual and factual	100%
		Fitting the requirement of PAKEM learning	62%
		Others	8%

6	Problem in implementing JAS approach	There is no big problem	15%
		The problem is the characteristics that have to be done	23%
		Evaluation problem	38%
		Time problem	77%
		Power problem	54%
		Others	31%
		- there are no difference criteria from CTL - the need to prepare of tools, equipment, and money	
7	The effort to fix the problem in number 6?	Nothing can be done yet	15%
		Reducing JAS characteristic	23%
		Ask the observer in exploration activity	31%
		Increase the time allocation outside the determined hour	31%
		Implementing peer assessment	23%
		Implementing self-assessment	31%
		Others	15%
8	Data exposure of the respondent's suggestions to fix the JAS approach.		
	<p>JAS is an approach that still needs to be tested again about how to implement it in the learning process. Therefore, it needs some clear criteria about JAS approach that make it different from another approach so that JAS is not just the other name of CTL. For example, JAS learning characteristic in question number 2. There is an addition of inquiry and learning community. JAS approach can be well implemented if those 6 components (exploration, science process, constructivism, learning community, and authentic assessment) integrated into both indoor and outdoor learning. The academic paper about JAS needs to be perfected with the deeper scientific study including the results of research that have been done. Biology Department can provide the knowledge/special guidance that can help the teachers so they can apply JAS. Work from Biology Lecturer group of UNNES and support from FMIPA and LP2M are needed.</p>		
9	Percentage of knowledge suitability and skill from JAS approach Implementation	> 86%	23%
		76 to 85%	38%
		61% to 75%	31%
		51% to 59 %	0%
		≤ 50%	8%
10	First source of information about JAS approach	Major/Faculty	54%
		Lecturer	31%
		Electronic media	8%
		From JAS development team	15%

11	The need of English in implementing JAS approach	Highly needed	8%
		Needed	46%
		Fairly needed	15%
		Not so needed	8%
		Not needed	23%
12	The need of technology of information in JAS approach implementation	Highly needed	31%
		Needed	46%
		Not needed	15%
13	Knowledge and skill that have been gotten from JAS approach implementation follow the educational Science and Technology development	Yes	77%
		No	23%
14	The assessment about the beneficial level that you get from JAS approach implementation		Per-centage
	Aspects of benefit	Beneficial level	
	The technical/practical ability in learning process	Very useful	38%
		Useful	23%
		Quite useful	31%
		Not so useful	8%
		Not useful	0%
	Theoretical knowledge	Very useful	15%
		Useful	38%
		Quite useful	38%
		Not so useful	8%
		Not useful	0%
	High prestige	Very useful	38%
		Useful	15%
		Quite useful	38%
		Not so useful	8%
		Not useful	0%
	Self-esteem	Very useful	38%
		Useful	31%
		Quite useful	23%
		Not so useful	0%
		Not useful	0%
	Work achievement appraisal	Very useful	15%
		Useful	23%
		Quite useful	38%
		Not so useful	15%
		Not useful	0%



Fast career progress	Very useful	15%
	Useful	8%
	Quite useful	38%
	Not so useful	23%
	Not useful	8%
High cross field mobile ability	Very useful	15%
	Useful	15%
	Quite useful	38%
	Not so useful	23%
	Not useful	8%

#### 15 Data exposure about the other things that the respondents have delivered related to JAS

In the last 4 years, JAS as an approach never to be touched again for getting fixed so it can be more applicative in the field. Therefore, it needs to create a deep study about the main characteristics of JAS that differentiate it from another approach, when to be applied, where, in what level, what kind of condition, what kind of students, outlined about the plus and minus of JAS approach. Do not let the kind of perception that whatever ideal is JAS. JAS should be capable of fixing the known weaknesses.

Biology Department of UNNES should be capable of bringing JAS to schools in the form of dedication towards the society. However, the Department needs to start from the inside where the lecturers and the students need to understand every lecture. We must be sure that JAS is suitable to be applied in lecturing. As a mother of JAS approach, Biology Department should strengthen the will to implement JAS approach in every lecture. The lecturers should be a role model for the students in implementing JAS approach in the class room.

The commitment of academician in the department to analyze the characteristics of JAS as written in the legal document are exploration, constructivism, science process, learning community, edutainment, authentic assessment. The department should push its academicians to publish the results of the researches more whether its journals or textbooks which related to JAS.

### CONCLUSION

Many types of research using many methods and approaches like qualitative descriptive, quasi-experiment, PTK, and R and D resulting prove that JAS approach is effective when implemented in learning process especially in Biology in many materials.

The meta-analysis result shows the effectiveness of Jas implementation proved in 97% of researches about JAS. Many types of research proved JAS approach succeeded in increasing the study result, can differentiate the resulting study between experiment class and control class where the experiment class has a higher average score.

Learning model/strategy/method that centered in the students are very relevant in implementing JAS approach so it looks more real, like cooperative learning model, think pair share, role playing strategy, group investigation,

learning cycle 5e, hands-on activity, and so on, so it make it possible to be kept studied and developed in curriculum paradigm that being developed with competence base. However, the users still got some difficulties in time and power allocation. Because of that, Biology Department is pushed to keep doing the study towards JAS approach implementation.

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## DISCOVERING LEARNING STRATEGY TO INCREASE METACOGNITIVE KNOWLEDGE ON BIOLOGY LEARNING IN SECONDARY SCHOOL

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### ABSTRACT

The study is aimed at finding an effective learning strategy that can increase metacognitive knowledge. Metacognitive knowledge is a standard that based on 2016-revised edition of 2013 curriculum needs to be achieved by every graduate in all level of education in Indonesia. The study is conducted in three different schools and engages 207 students, which then divided into six groups. The groups are students who study under mind mapping strategy, concept mapping, reciprocal teaching using summary notes, reciprocal teaching using mind mapping, problem-based learning, and investigation group. The results showed that those studying under problem-based learning strategy spent a significantly higher numbers in metacognitive knowledge in biology learning and followed by students who study under reciprocal teaching using mind mapping. According to the finding, it is expected that teachers of Biology will practice problem-based learning strategy in their classroom in order to increase the Metacognitive knowledge.

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**Keywords:** metacognitive knowledge; group investigation; reciprocal teaching; mind map; concept map; problem-based learning

### INTRODUCTION

Metacognitive knowledge is an important component in the accomplishment of Indonesian graduation standard in 2013 curriculum. According to the decree of Minister of Education and Culture Number 20 in 2016 about the graduation standard, it states that in the high school level a graduate should be equipped with factual, conceptual, procedural, and metacognitive knowledge in terms of technical, specific, detailed and complex level which relates to science, technology, arts, culture and humanities.

Metacognitive knowledge is a new dimension in Indonesian graduation standard. The 2006 curriculum covers factual, conceptual and

procedural knowledge which made the ability of higher order thinking of Indonesian students is quite poor.

One of the indicators can be seen in science literacy. According to Program for International Assessment (PISA) in 2012, the Indonesian students' science literacy ranked 64<sup>th</sup> from 65 countries and its score below World average. The science literacy score of Indonesian students is the lowest of all South East Asian Countries, such as Malaysia (ranked 52), Singapore (ranked 2), Vietnam (ranked 17), and Thailand (ranked 50). Metacognitive has been included in the graduation standard so that it will be able to increase the students' higher order thinking. It is in accordance with Livingston (1997:3) who states that metacognition refers to higher order thinking which involves active control over the cognitive processes engaged in learning.

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The definition of metacognitive knowledge according to the decree of Minister of Education and Culture Number 20 in 2016 is knowledge about one's cognitive strengths or weaknesses and how to utilize it in learning technical, detailed, specific, complex, contextual and conditional knowledge about science, technology, arts, and culture which relates to the society and environment, nation and state, regional and international. The definition states that metacognitive knowledge is *self regulated process*. Relationship between self regulated and metacognitive knowledge was explained by Artelt, Weinert, & Handel, (2013:162) reading or mathematical literacy. Metacognition is a central component in the process of self-regulated learning. It is defined as cognition about cognition and encompasses two components: the knowledge component and the regulation component.

Metacognitive knowledge of tasks operates when the nature of task forces us to think about how we will manage (Jayapraba & Kanmani, 1998:48). Rompayom, Tambunchong, Wongyounoi, & Dechsri (2010:213) divides knowledge into three categories, namely knowledge about your own self or individuals (declarative knowledge), knowledge of the tasks or activities (procedural knowledge) and knowledge of learning strategies (conditional knowledge). Declarative knowledge refers to the knowledge that learners have about the information of resources needed for undertaking the given tasks. Procedural knowledge refers to knowledge of beliefs about us about given task; an individual's self-perceptions of one's capacity of how to do something. Conditional knowledge refers to knowledge concerning when and why to use strategies to solve problems.

To increase their metacognitive abilities, students need to possess and be aware of three kinds of content knowledge: declarative, procedural, and conditional. This notion of three kinds of knowledge applies to learning strategies (Pierce, 2003). Some of research recommended some strategies to increase metacognitive knowledge.

Pintrich (2016:223) recommends comprehensive reading competence which is really effective as metacognitive knowledge learning strategy, especially in a group discussion. According to Doolittle, Hicks, Triplett, Young, & Tech (2006:115), comprehensive reading can be done by using reciprocal teaching. Choo, Eng, & Ahmad (2011:142) states that reciprocal teaching is based on active socialization, wherein the knowledge constructed from the text is negotiated within discourse communities through

both teacher student and student-student interactions. Furthermore, there are four steps in reciprocal teaching strategy (Garderen, 2004:26). They are summarizing, clarifying, integrating, and elaborating. Furthermore, Agoro, (2013:5) have developed reciprocal teaching as a strategy which consists of three main components: (a) the teaching and learning of specific concept and the strategies (b) the dialogue between an instructor and students about why, when, and where to use the strategies and (c) the appropriating of the role of the instructor by the students, students begin to model the strategy for other students. Thus, the goals of reciprocal teaching are for students to learn the strategies, learn how and when to use the strategies and become self-regulated in the use of these strategies.

Novak & Cañas, (2008:1) suggests concept map as metacognitive learning strategy in science teaching. Concept mapping is a useful tool for helping students learn about concept that is built on a perceived regularity in events or objects, or records of events or objects, designated by a symbolic label and word to describe the structure of concept map. Concept mapping helps students in improving metacognitive knowledge as stated by Vanides, Yin, Tomita, Ruiz-Primo, (2005:28) that concept maps give students an opportunity to: (1) think about the connections between the science terms being learned, (2) organize their thoughts and visualize the relationships between key concepts in a systematic way, and (3) reflect on their understanding.

Adodo (2013:170) also stated that concept mapping is useful as Self Regulating Learning (SLR) media. SLR is a part of metacognitive strategy. Self-regulating occurs when concept mapping provides students an opportunity to explore relationships between ideas and elements of an argument and to generate solutions to problems (Buzan, 2012:8). Additionally Evrekli, Balim, & Inel (2009:2279) presented that mind map can facilitate to recall knowledge and conceptions and the interrelations set between them.

Another learning method that is related to metacognitive is problem-based learning (PBL). PBL has used widely, because it has some advantages, PBL improved argument skill of students (Pritasari, Dwiastuti, & Probosari, 2015:154), creative thinking (Hartini, Kusdiwelirawan, & Fitriana, 2014:60), critical thinking (Fakhriah, 2013:94), and PBL strategy that enables student to solve a problem that potentially increases metacognitive knowledge (Pintrich, 2016:224). A study by Tosun & Senocak (2013:66-67) shows that after the implementation of problem-based

learning the three metacognitive knowledge indicators, i.e. declarative, procedural, and conditional knowledge, on high school-teacher candidates increase significantly. On the other hand, the metacognitive knowledge on elementary school-teacher candidates both before and after PBL implementation shows no difference. Problem-based learning increases metacognitive knowledge because students need to equip themselves with sufficient information in order to solve the problem. Problem-based learning requires self-directed learning skill. When individuals try to be self-directed learners, metacognitive thinking become important.

In Indonesia, Biology learning mostly applies Group Investigation approach. The approach is used since Biology content requires an investigation activity whether direct investigation by observation either on the field or laboratory, or indirect investigation by finding literatures on research that has been conducted by scholars. Group investigation is a compulsory menu in Biology. Hence, when some approaches need to be selected it is necessary to include group investigation as one them.

This study is aimed at finding several learning strategies that will be able to increase the students' metacognitive knowledge. The strategies are concept mapping, reciprocal teaching, problem-based learning and group investigation learning

**METHODS**

The research uses a quasi-experiment. A quasi-experimental design can be seen in the Table 1.

**Table 1.** A quasi-experimental Research Design

1:	O <sub>1</sub>	X <sub>1</sub>	O <sub>2</sub>
2:	O <sub>1</sub>	X <sub>2</sub>	O <sub>2</sub>
3:	O <sub>1</sub>	X <sub>3</sub>	O <sub>2</sub>
4:	O <sub>1</sub>	X <sub>4</sub>	O <sub>2</sub>
5:	O <sub>1</sub>	X <sub>5</sub>	O <sub>2</sub>
6:	O <sub>1</sub>	X <sub>6</sub>	O <sub>2</sub>

note:

- X1 = scientific approach with mind map
- X2 = scientific approach with concept map
- X3 = Reciprocal Teaching with summary note
- X4 = Reciprocal Teaching with mind map
- X5 = Problem-based learning
- X6 = Group Investigation
- O<sub>1</sub> = Pre test
- O<sub>2</sub> = Post test

The research engages three senior high schools in Jakarta and South Tangerang. The target population is students in grade 10 of Science program. The research sample uses simple random sampling, which based on group of subject and the participants are 207 students.

The data collected from learning outcomes on pre and post test. The test items are created according to basic competence of 2013 curriculum. Metacognitive inquiries are developed from Rampoyam et al. (2010). There are 16 inquiries assigned and arranged based on the difficulty levels. 6.25% belongs to easy, 37.5% belongs to moderate and 56.25% belongs to difficult. Table 3 shows the test items framework and the inquiry examples.

The data is analyzed on one way ANOVA. When it is known that the data has normal distribution, it is then tested using Shapiro-Wilk normality test (pre test = 0.97 Sig 0.00; post test = 0.99 Sig 0.078). Then, the post-hoc test is using Tukey test. Data analysis in ANOVA and Tukey's Post Hoc Test is used to find the distinction between one experimental group and the other group. Data analysis is conducted by SPSS program. Furthermore, the data is analyzed in Normalized Learning Gain (Meltzer, 2002:7) and according to (Hake, 1999:1) the category of the learning improvement belongs to high, medium and low. Normalized learning gain analysis and its category is used to find the improvement in cognitive knowledge both before and after the learning process. The formula of Normalized Learning Gain is:

$$gain = \frac{posttest\ score - pretest\ score}{maximum\ possible\ score - pretest\ score}$$

- High-g courses as those with (<g>) > 0.7
- Medium-g courses as those with 0.7 > (<g>) > 0.3
- Low-g courses as those with (<g>) < 0.3.

**RESULT AND DISCUSSION**

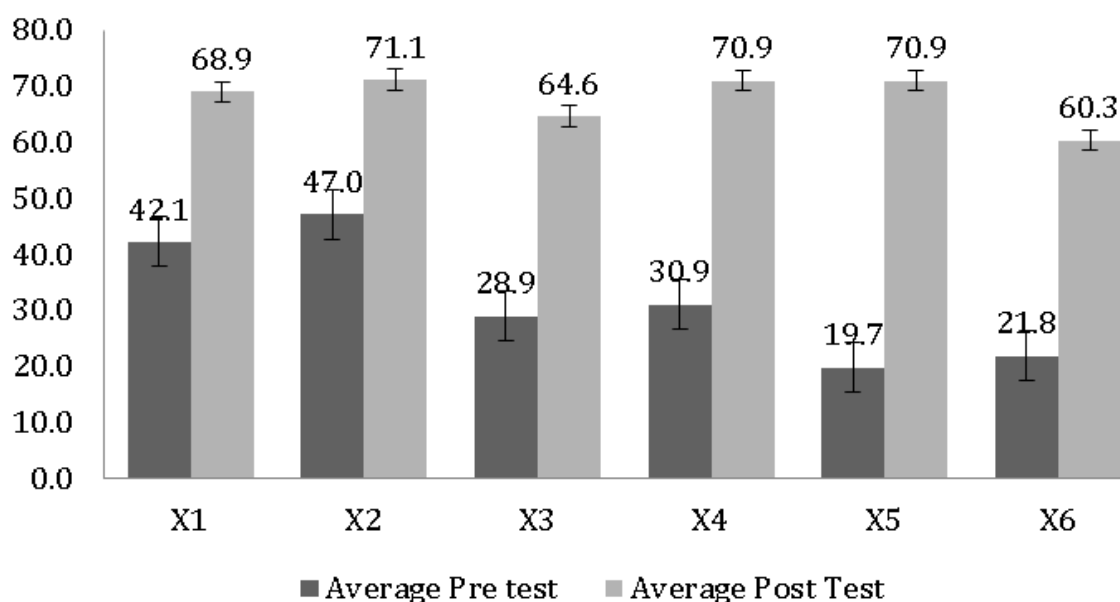
Descriptively the result of pre and post test can be seen in Figure 1. It shows that the average score on the pre test of X1 and X2 groups and the other groups has quite ample difference in the average score i.e. 20 point. Whereas on the post test, the score difference of the inter-group is not more than 10 point. Figure 1 also describes that X5 group show the highest improvement among the other groups. Even though X5 group has the lowest score in the pre test, its post test is slightly increasing. Aside from that, Figure 1 shows that

**Table 2.** Population, Sample, and Number of Samples

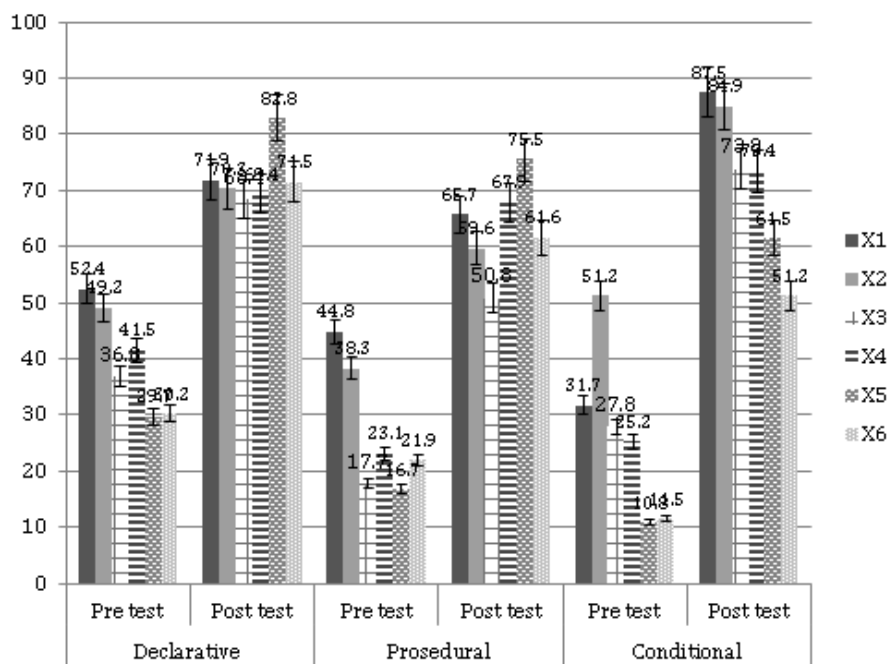
	School	Number of Science Program in 10 <sup>th</sup> Grade Class Program	Sample	
			Number of student in Class	
A	South Jakarta School I	3	Science Class II	31
			Science Class III	32
B	South Tangerang School	5	Science Class II	36
			Science Class III	36
C	South Jakarta School II	4	Science Class I	36
			Science Class IV	36
Sum		12	207	

**Table 3.** The test items framework and the inquiry examples

Basic competence	Inquiry Indicator	Cognitive Aspect	Inquiry illustration
Implementing an understanding about the virus which relates to its features, replication, and roles in community health aspect.	Explaining the reason and objective of creating virus history	C4	Why is there a chronology of virus history in Biology textbook? (Choose the best answer!) 1. Virus is historical heritage 2. Virus is science 3. Virus causes plague
	Determining how to group the virus properly	C5	4. Respect the scholars who have great rule 5. Virus is the simplest form or organism
	Differentiating virus reproduction in lytic and lysogenic	C2	Metacognitive knowledge inquiries 1. What do you need to know earlier to be able to answer inquiries properly? 2. How do you find the solution which is like the previous inquiry?
	Organizing the best way to prevent virus	C3	3. When will you answer as in part (b)? Why do you use such method?



**Figure 1.** Average Pre test and Post Test



**Figure 2.** Performance of Metacognitive Knowledge

X2 group has the lowest improvement.

According to the aspect details of metacognitive knowledge, the result of pre test and post test has indicated in Figure 2. The figure shows that there is no similar pattern among groups. Each group has its own prominence. X1, X2, X3, and X4 groups have an outstanding aspect in conditional knowledge. While X5 and X6 groups have an excellent aspect in declarative knowledge. Moreover, these two groups also have a prominent aspect in procedural knowledge compare to the other groups.

Students who participate in the study come from different schools; however, each school has one similarity, i.e. it has been the pilot project for 2013 curriculum implementation. A test on each school-initial competency is required to find the difference on the students-initial competence in the three schools and six distinct grades. The result of ANOVA test shows significant difference in the inter-group ( $F= 35.18$  Sig. 0.00), whereas the Tukey's post-hoc test on Table 4 exposes the position of the difference in the inter-group. Table 4 describes that the difference of the initial competence occur both in the inter-school and inter-group. For instance in B and C school, there is some difference on the initial competence. X1 and X2 groups have significant difference though they are from the same school (A school). The similar situation happens on X3 and X4 groups which come from B school and also X5 and X6 groups from C school.

Based on the result of pre test on Table

4, the post hoc test on finding the most effective learning strategy cannot use the data from the post test. The data from the post test has some bias due to the impact of the initial competence of the students which is different though they are in the same group. To avert the bias, gain (the pre test and post test excess) is applied.

The result of inter-group different test by applying gain shows significant difference in the inter-group (ANOVA ONE WAY,  $F=18.15$  Sig. 0.00). Table 4 shows Tukey's post hoc test for metacognitive knowledge's gain.

Table 5 exposes the significant difference in the groups which use various learning strategies. According to Tukey's post hoc test, it is known that significant difference occur in X1-X4, X1-X5, X1-X6, X2-X4, X2-X5, X2-X6, X3-X5, dan X5-X6 groups. The result of N-Gain test can be seen in Table 6. According to Table 6, X4 and X5 groups have the highest gain increase with the excess more than 10 point of the other groups. Whereas the other groups, i.e. X1, X2, X3, and X6 have the excess of the inter-group around 1 point. According to low, medium and high group distribution, Table 6 shows that in X5 group the improvement of metacognitive knowledge is distributed in medium and high group. It means that 100% students belong to medium and high category in the improvement of their metacognitive knowledge. Moreover, it also explains the effective learning strategy used to increase the students' metacognitive knowledge. In X4 and X6 groups have few students who belong to low



**Table 4.** p value of Metacognitive knowledge Pre-Test in Tukey Test

School	Group	A		B		C	
		X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>
A	X <sub>1</sub>		0.44	0.00	0.00	0.00	0.00
	X <sub>2</sub>			0.00	0.00	0.00	0.00
B	X <sub>3</sub>				0.97	0.005	0.00
	X <sub>4</sub>					0.05	0.004
C	X <sub>5</sub>						0.96
	X <sub>6</sub>						

**Table 5.** Significance Score based on ANOVA and Tukey's test Metacognitive knowledge's Gain

	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>
X <sub>1</sub>		0.96	0.32	0.00	0.00	0.00
X <sub>2</sub>			0.04	0.00	0.00	0.00
X <sub>3</sub>				0.12	0.00	0.68
X <sub>4</sub>					0.06	0.89
X <sub>5</sub>						0.00
X <sub>6</sub>						

**Table 6.** The Result of N-Gain Test's Average and Distribution According to N-Gain Attainment Category.

Group	Average	n-Gain						Sum (n)
		Criteria						
		Low		Medium		High		
		People (n)	Percentage (%)	People (n)	Percentage (%)	People (n)	Percentage (%)	
X <sub>1</sub>	0.45	6	19.4	20	64.5	5	16.1	31
X <sub>2</sub>	0.46	8	25.0	18	56.3	6	18.7	32
X <sub>3</sub>	0.47	6	16.7	27	75.0	3	8.3	36
X <sub>4</sub>	0.58	2	5.6	28	77.8	6	16.7	36
X <sub>5</sub>	0.65	0	0	24	66.7	12	33.3	36
X <sub>6</sub>	0.50	3	8.3	29	80.6	4	11.1	36

on the N-Gain improvement category. It means that more than 90% students show medium and high improvement on metacognitive knowledge even though X<sub>6</sub> group, according to N-Gain average result, has lower score than X<sub>4</sub>. According to Tukey test (Table 5) X<sub>4</sub>, X<sub>5</sub> and X<sub>6</sub> groups are hardly different. On the other hand, in X<sub>3</sub> group more than 80% students show improvement in their metacognitive knowledge. It means that the learning strategy applied in this group is categorized as effective to increase students' metacognitive knowledge as the one used in X<sub>4</sub> and X<sub>5</sub> groups. This is indicated by the absence of a significant difference between the groups X<sub>3</sub> with X<sub>4</sub> and X<sub>6</sub> on Tukey's test (Table 5).

The most effective strategies to increase

students' metacognitive knowledge are problem-based learning, reciprocal teaching and group investigation. Reciprocal teaching with mind mapping is more effective than with the usual note taking. Problem-based learning is most effective strategy in improving metacognitive knowledge since the strategy has several steps that correlate with metacognitive knowledge. Rahayu & Azizah (2012:167) stated that there are three phases and seven syntaxes of problem-based learning about metacognitive knowledge. Table 7 explains the relation of metacognitive knowledge, syntax and problem-based learning phases.

Another effective learning strategy is reciprocal teaching. Reciprocal teaching focuses neither on the discovery activity nor the knowled-

**Table 7.** The relation of metacognitive knowledge and problem-based learning syntax

Metacognitive knowledge	Syntax of Problem-based learning	Phase of Problem-based learning
Declarative knowledge	Exploring students' prior knowledge by having students to do Self-Understanding Assessment Question	Organize the student for study
	Asking students to collect all information related to the formulation of the problem in groups	
Procedural knowledge	Guiding students to observe/practice	Assist independent and group investigation
	Guiding students to do analysis and make conclusion to find explanations and solutions to the problem	
Declarative knowledge	Guiding students who have acquired the knowledge revealed from observations and analysis by asking the students do the Self-Understanding Assessment Questions and application question contained in the worksheet.	Analyze and evaluate the problem-solving process
	Guiding students to reflect or evaluate the learning process they use	
	Guiding students to conclude the learning outcomes (declarative,	

Source: Rahayu & Azizah (2012: 67)

ge construction. It focuses more on the reflection activities, i.e. questioning, clarifying, summarizing and predicting (Cooper & Greive, 2009:45). Agoro & Akinsola (2013:5) said that Reciprocal Teaching consists of the main component that describe metacognitive strategy. The component is the dialogue between an instructor and students where the instructor models why, when, and where to use the strategies. The practice of reciprocal teaching with mind mapping optimizes the students' metacognitive knowledge improvement. The application of mind mapping makes the information distributed on students' mind more structured as stated by Buzan (2012:8) mind map puts a new perspective on things by allowing you to see all the relevant issues and analyses choices in light of the big picture. Mind map also becomes easier to integrate new knowledge and organize information logically as you aren't tied to a rigid structure.

Furthermore, group investigation learning is the other effective strategy in improving metacognitive knowledge. Group investigation learning is discovery learning that gives students opportunities to construct knowledge in a group. Sharan & Sharan (1989:17) explained that in group investigation students take an active part in planning what they will study and how. All group members help plan how to research their topic. The discovery activity and knowledge construction in group investigation learning enable students to actively control their cognitive activities. The ability in utilizing cognitive activity control makes students' academic performan-

ce and achievement become higher (Jayaprabha & Kanmani, 1998:48).

## CONCLUSION

Problem based learning is one of the most effective strategies in improving metacognitive knowledge. Another strategy is reciprocal teaching with mind mapping. Meanwhile a group investigation is a strategy that is mostly practiced by teachers of Biology as it is literally effective to increase metacognitive knowledge.

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## DISCOVERING LEARNING STRATEGY TO INCREASE METACOGNITIVE KNOWLEDGE ON BIOLOGY LEARNING IN SECONDARY SCHOOL

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### ABSTRACT

The study is aimed at finding an effective learning strategy that can increase metacognitive knowledge. Metacognitive knowledge is a standard that based on 2016-revised edition of 2013 curriculum needs to be achieved by every graduate in all level of education in Indonesia. The study is conducted in three different schools and engages 207 students, which then divided into six groups. The groups are students who study under mind mapping strategy, concept mapping, reciprocal teaching using summary notes, reciprocal teaching using mind mapping, problem-based learning, and investigation group. The results showed that those studying under problem-based learning strategy spent a significantly higher numbers in metacognitive knowledge in biology learning and followed by students who study under reciprocal teaching using mind mapping. According to the finding, it is expected that teachers of Biology will practice problem-based learning strategy in their classroom in order to increase the Metacognitive knowledge.

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**Keywords:** metacognitive knowledge; group investigation; reciprocal teaching; mind map; concept map; problem-based learning

### INTRODUCTION

Metacognitive knowledge is an important component in the accomplishment of Indonesian graduation standard in 2013 curriculum. According to the decree of Minister of Education and Culture Number 20 in 2016 about the graduation standard, it states that in the high school level a graduate should be equipped with factual, conceptual, procedural, and metacognitive knowledge in terms of technical, specific, detailed and complex level which relates to science, technology, arts, culture and humanities.

Metacognitive knowledge is a new dimension in Indonesian graduation standard. The 2006 curriculum covers factual, conceptual and

procedural knowledge which made the ability of higher order thinking of Indonesian students is quite poor.

One of the indicators can be seen in science literacy. According to Program for International Assessment (PISA) in 2012, the Indonesian students' science literacy ranked 64<sup>th</sup> from 65 countries and its score below World average. The science literacy score of Indonesian students is the lowest of all South East Asian Countries, such as Malaysia (ranked 52), Singapore (ranked 2), Vietnam (ranked 17), and Thailand (ranked 50). Metacognitive has been included in the graduation standard so that it will be able to increase the students' higher order thinking. It is in accordance with Livingston (1997:3) who states that metacognition refers to higher order thinking which involves active control over the cognitive processes engaged in learning.

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The definition of metacognitive knowledge according to the decree of Minister of Education and Culture Number 20 in 2016 is knowledge about one's cognitive strengths or weaknesses and how to utilize it in learning technical, detailed, specific, complex, contextual and conditional knowledge about science, technology, arts, and culture which relates to the society and environment, nation and state, regional and international. The definition states that metacognitive knowledge is *self regulated process*. Relationship between self regulated and metacognitive knowledge was explained by Artelt, Weinert, & Handel, (2013:162) reading or mathematical literacy. Metacognition is a central component in the process of self-regulated learning. It is defined as cognition about cognition and encompasses two components: the knowledge component and the regulation component.

Metacognitive knowledge of tasks operates when the nature of task forces us to think about how we will manage (Jayapraba & Kanmani, 1998:48). Rompayom, Tambunchong, Wongyounoi, & Dechsri (2010:213) divides knowledge into three categories, namely knowledge about your own self or individuals (declarative knowledge), knowledge of the tasks or activities (procedural knowledge) and knowledge of learning strategies (conditional knowledge). Declarative knowledge refers to the knowledge that learners have about the information of resources needed for undertaking the given tasks. Procedural knowledge refers to knowledge of beliefs about us about given task; an individual's self-perceptions of one's capacity of how to do something. Conditional knowledge refers to knowledge concerning when and why to use strategies to solve problems.

To increase their metacognitive abilities, students need to possess and be aware of three kinds of content knowledge: declarative, procedural, and conditional. This notion of three kinds of knowledge applies to learning strategies (Pierce, 2003). Some of research recommended some strategies to increase metacognitive knowledge.

Pintrich (2016:223) recommends comprehensive reading competence which is really effective as metacognitive knowledge learning strategy, especially in a group discussion. According to Doolittle, Hicks, Triplett, Young, & Tech (2006:115), comprehensive reading can be done by using reciprocal teaching. Choo, Eng, & Ahmad (2011:142) states that reciprocal teaching is based on active socialization, wherein the knowledge constructed from the text is negotiated within discourse communities through

both teacher student and student-student interactions. Furthermore, there are four steps in reciprocal teaching strategy (Garderen, 2004:26). They are summarizing, clarifying, integrating, and elaborating. Furthermore, Agoro, (2013:5) have developed reciprocal teaching as a strategy which consists of three main components: (a) the teaching and learning of specific concept and the strategies (b) the dialogue between an instructor and students about why, when, and where to use the strategies and (c) the appropriating of the role of the instructor by the students, students begin to model the strategy for other students. Thus, the goals of reciprocal teaching are for students to learn the strategies, learn how and when to use the strategies and become self-regulated in the use of these strategies.

Novak & Cañas, (2008:1) suggests concept map as metacognitive learning strategy in science teaching. Concept mapping is a useful tool for helping students learn about concept that is built on a perceived regularity in events or objects, or records of events or objects, designated by a symbolic label and word to describe the structure of concept map. Concept mapping helps students in improving metacognitive knowledge as stated by Vanides, Yin, Tomita, Ruiz-Primo, (2005:28) that concept maps give students an opportunity to: (1) think about the connections between the science terms being learned, (2) organize their thoughts and visualize the relationships between key concepts in a systematic way, and (3) reflect on their understanding.

Adodo (2013:170) also stated that concept mapping is useful as Self Regulating Learning (SLR) media. SLR is a part of metacognitive strategy. Self-regulating occurs when concept mapping provides students an opportunity to explore relationships between ideas and elements of an argument and to generate solutions to problems (Buzan, 2012:8). Additionally Evrekli, Balim, & Inel (2009:2279) presented that mind map can facilitate to recall knowledge and conceptions and the interrelations set between them.

Another learning method that is related to metacognitive is problem-based learning (PBL). PBL has used widely, because it has some advantages, PBL improved argument skill of students (Pritasari, Dwiastuti, & Probosari, 2015:154), creative thinking (Hartini, Kusdiwelirawan, & Fitriana, 2014:60), critical thinking (Fakhriah, 2013:94), and PBL strategy that enables student to solve a problem that potentially increases metacognitive knowledge (Pintrich, 2016:224). A study by Tosun & Senocak (2013:66-67) shows that after the implementation of problem-based

learning the three metacognitive knowledge indicators, i.e. declarative, procedural, and conditional knowledge, on high school-teacher candidates increase significantly. On the other hand, the metacognitive knowledge on elementary school-teacher candidates both before and after PBL implementation shows no difference. Problem-based learning increases metacognitive knowledge because students need to equip themselves with sufficient information in order to solve the problem. Problem-based learning requires self-directed learning skill. When individuals try to be self-directed learners, metacognitive thinking become important.

In Indonesia, Biology learning mostly applies Group Investigation approach. The approach is used since Biology content requires an investigation activity whether direct investigation by observation either on the field or laboratory, or indirect investigation by finding literatures on research that has been conducted by scholars. Group investigation is a compulsory menu in Biology. Hence, when some approaches need to be selected it is necessary to include group investigation as one them.

This study is aimed at finding several learning strategies that will be able to increase the students' metacognitive knowledge. The strategies are concept mapping, reciprocal teaching, problem-based learning and group investigation learning

**METHODS**

The research uses a quasi-experiment. A quasi-experimental design can be seen in the Table 1.

**Table 1.** A quasi-experimental Research Design

1:	O <sub>1</sub>	X <sub>1</sub>	O <sub>2</sub>
2:	O <sub>1</sub>	X <sub>2</sub>	O <sub>2</sub>
3:	O <sub>1</sub>	X <sub>3</sub>	O <sub>2</sub>
4:	O <sub>1</sub>	X <sub>4</sub>	O <sub>2</sub>
5:	O <sub>1</sub>	X <sub>5</sub>	O <sub>2</sub>
6:	O <sub>1</sub>	X <sub>6</sub>	O <sub>2</sub>

note:

- X1 = scientific approach with mind map
- X2 = scientific approach with concept map
- X3 = Reciprocal Teaching with summary note
- X4 = Reciprocal Teaching with mind map
- X5 = Problem-based learning
- X6 = Group Investigation
- O<sub>1</sub> = Pre test
- O<sub>2</sub> = Post test

The research engages three senior high schools in Jakarta and South Tangerang. The target population is students in grade 10 of Science program. The research sample uses simple random sampling, which based on group of subject and the participants are 207 students.

The data collected from learning outcomes on pre and post test. The test items are created according to basic competence of 2013 curriculum. Metacognitive inquiries are developed from Rampoyam et al. (2010). There are 16 inquiries assigned and arranged based on the difficulty levels. 6.25% belongs to easy, 37.5% belongs to moderate and 56.25% belongs to difficult. Table 3 shows the test items framework and the inquiry examples.

The data is analyzed on one way ANOVA. When it is known that the data has normal distribution, it is then tested using Shapiro-Wilk normality test (pre test = 0.97 Sig 0.00; post test = 0.99 Sig 0.078). Then, the post-hoc test is using Tukey test. Data analysis in ANOVA and Tukey's Post Hoc Test is used to find the distinction between one experimental group and the other group. Data analysis is conducted by SPSS program. Furthermore, the data is analyzed in Normalized Learning Gain (Meltzer, 2002:7) and according to (Hake, 1999:1) the category of the learning improvement belongs to high, medium and low. Normalized learning gain analysis and its category is used to find the improvement in cognitive knowledge both before and after the learning process. The formula of Normalized Learning Gain is:

$$gain = \frac{posttest\ score - pretest\ score}{maximum\ possible\ score - pretest\ score}$$

- High-g courses as those with (<g>) > 0.7
- Medium-g courses as those with 0.7 > (<g>) > 0.3
- Low-g courses as those with (<g>) < 0.3.

**RESULT AND DISCUSSION**

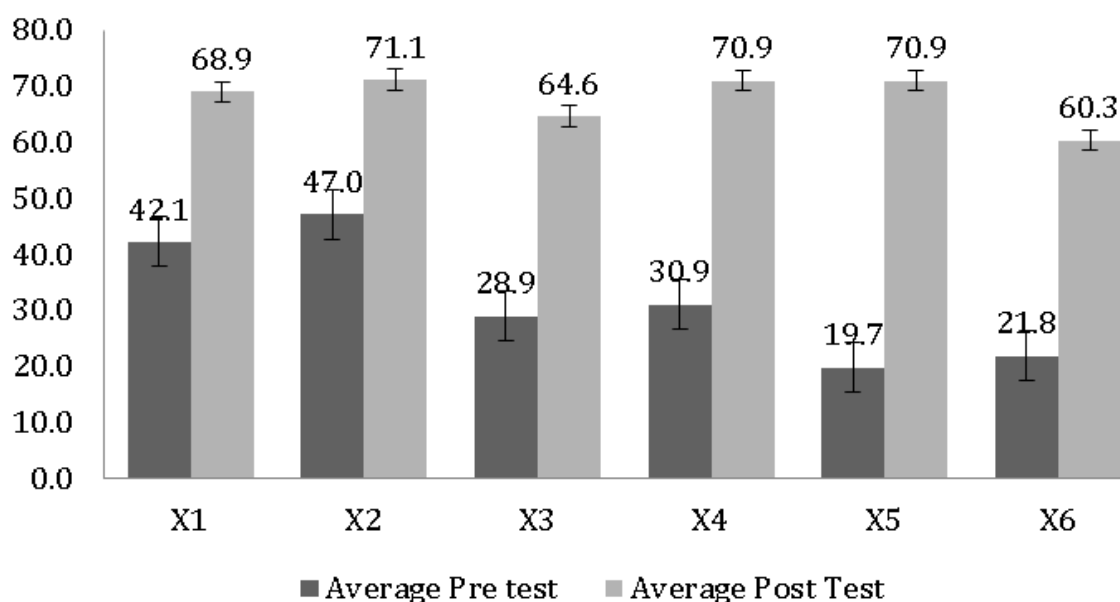
Descriptively the result of pre and post test can be seen in Figure 1. It shows that the average score on the pre test of X1 and X2 groups and the other groups has quite ample difference in the average score i.e. 20 point. Whereas on the post test, the score difference of the inter-group is not more than 10 point. Figure 1 also describes that X5 group show the highest improvement among the other groups. Even though X5 group has the lowest score in the pre test, its post test is slightly increasing. Aside from that, Figure 1 shows that

**Table 2.** Population, Sample, and Number of Samples

	School	Number of Science Program in 10 <sup>th</sup> Grade Class Program	Sample	
			Number of student in Class	
A	South Jakarta School I	3	Science Class II	31
			Science Class III	32
B	South Tangerang School	5	Science Class II	36
			Science Class III	36
C	South Jakarta School II	4	Science Class I	36
			Science Class IV	36
Sum		12	207	

**Table 3.** The test items framework and the inquiry examples

Basic competence	Inquiry Indicator	Cognitive Aspect	Inquiry illustration
Implementing an understanding about the virus which relates to its features, replication, and roles in community health aspect.	Explaining the reason and objective of creating virus history	C4	Why is there a chronology of virus history in Biology textbook? (Choose the best answer!) 1. Virus is historical heritage 2. Virus is science 3. Virus causes plague
	Determining how to group the virus properly	C5	4. Respect the scholars who have great rule 5. Virus is the simplest form or organism
	Differentiating virus reproduction in lytic and lysogenic	C2	Metacognitive knowledge inquiries 1. What do you need to know earlier to be able to answer inquiries properly? 2. How do you find the solution which is like the previous inquiry?
	Organizing the best way to prevent virus	C3	3. When will you answer as in part (b)? Why do you use such method?

**Figure 1.** Average Pre test and Post Test

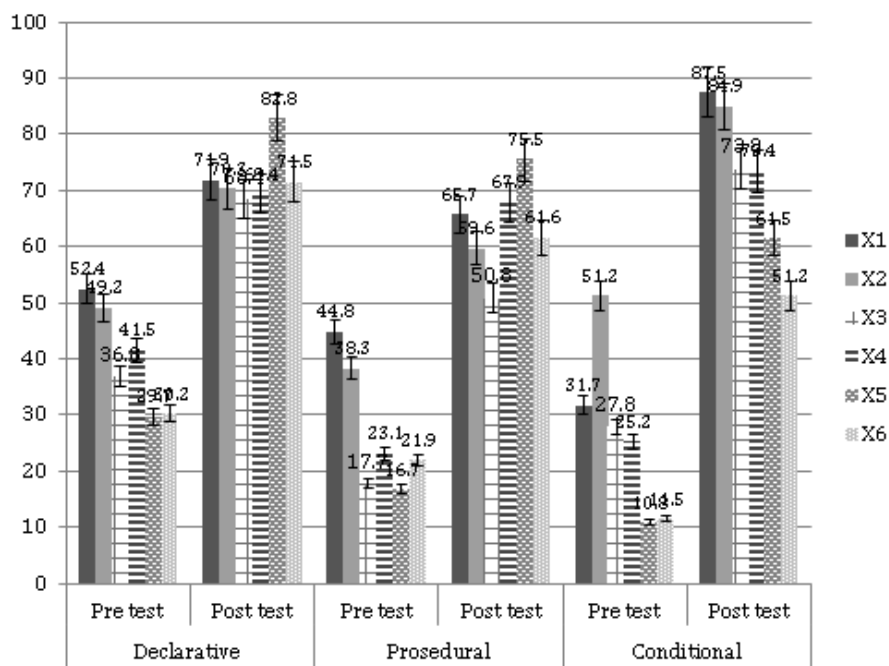


Figure 2. Performance of Metacognitive Knowledge

X2 group has the lowest improvement.

According to the aspect details of metacognitive knowledge, the result of pre test and post test has indicated in Figure 2. The figure shows that there is no similar pattern among groups. Each group has its own prominence. X1, X2, X3, and X4 groups have an outstanding aspect in conditional knowledge. While X5 and X6 groups have an excellent aspect in declarative knowledge. Moreover, these two groups also have a prominent aspect in procedural knowledge compare to the other groups.

Students who participate in the study come from different schools; however, each school has one similarity, i.e. it has been the pilot project for 2013 curriculum implementation. A test on each school-initial competency is required to find the difference on the students-initial competence in the three schools and six distinct grades. The result of ANOVA test shows significant difference in the inter-group ( $F= 35.18$  Sig. 0.00), whereas the Tukey's post-hoc test on Table 4 exposes the position of the difference in the inter-group. Table 4 describes that the difference of the initial competence occur both in the inter-school and inter-group. For instance in B and C school, there is some difference on the initial competence. X1 and X2 groups have significant difference though they are from the same school (A school). The similar situation happens on X3 and X4 groups which come from B school and also X5 and X6 groups from C school.

Based on the result of pre test on Table

4, the post hoc test on finding the most effective learning strategy cannot use the data from the post test. The data from the post test has some bias due to the impact of the initial competence of the students which is different though they are in the same group. To avert the bias, gain (the pre test and post test excess) is applied.

The result of inter-group different test by applying gain shows significant difference in the inter-group (ANOVA ONE WAY,  $F=18.15$  Sig. 0.00). Table 4 shows Tukey's post hoc test for metacognitive knowledge's gain.

Table 5 exposes the significant difference in the groups which use various learning strategies. According to Tukey's post hoc test, it is known that significant difference occur in X1-X4, X1-X5, X1-X6, X2-X4, X2-X5, X2-X6, X3-X5, dan X5-X6 groups. The result of N-Gain test can be seen in Table 6. According to Table 6, X4 and X5 groups have the highest gain increase with the excess more than 10 point of the other groups. Whereas the other groups, i.e. X1, X2, X3, and X6 have the excess of the inter-group around 1 point. According to low, medium and high group distribution, Table 6 shows that in X5 group the improvement of metacognitive knowledge is distributed in medium and high group. It means that 100% students belong to medium and high category in the improvement of their metacognitive knowledge. Moreover, it also explains the effective learning strategy used to increase the students' metacognitive knowledge. In X4 and X6 groups have few students who belong to low



**Table 4.** p value of Metacognitive knowledge Pre-Test in Tukey Test

School	Group	A		B		C	
		X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>
A	X <sub>1</sub>		0.44	0.00	0.00	0.00	0.00
	X <sub>2</sub>			0.00	0.00	0.00	0.00
B	X <sub>3</sub>				0.97	0.005	0.00
	X <sub>4</sub>					0.05	0.004
C	X <sub>5</sub>						0.96
	X <sub>6</sub>						

**Table 5.** Significance Score based on ANOVA and Tukey's test Metacognitive knowledge's Gain

	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>
X <sub>1</sub>		0.96	0.32	0.00	0.00	0.00
X <sub>2</sub>			0.04	0.00	0.00	0.00
X <sub>3</sub>				0.12	0.00	0.68
X <sub>4</sub>					0.06	0.89
X <sub>5</sub>						0.00
X <sub>6</sub>						

**Table 6.** The Result of N-Gain Test's Average and Distribution According to N-Gain Attainment Category.

Group	Average	n-Gain						Sum (n)
		Criteria						
		Low		Medium		High		
		People (n)	Percentage (%)	People (n)	Percentage (%)	People (n)	Percentage (%)	
X <sub>1</sub>	0.45	6	19.4	20	64.5	5	16.1	31
X <sub>2</sub>	0.46	8	25.0	18	56.3	6	18.7	32
X <sub>3</sub>	0.47	6	16.7	27	75.0	3	8.3	36
X <sub>4</sub>	0.58	2	5.6	28	77.8	6	16.7	36
X <sub>5</sub>	0.65	0	0	24	66.7	12	33.3	36
X <sub>6</sub>	0.50	3	8.3	29	80.6	4	11.1	36

on the N-Gain improvement category. It means that more than 90% students show medium and high improvement on metacognitive knowledge even though X6 group, according to N-Gain average result, has lower score than X4. According to Tukey test (Table 5) X4, X5 and X6 groups are hardly different. On the other hand, in X3 group more than 80% students show improvement in their metacognitive knowledge. It means that the learning strategy applied in this group is categorized as effective to increase students' metacognitive knowledge as the one used in X4 and X5 groups. This is indicated by the absence of a significant difference between the groups X3 with X4 and X6 on Tukey's test (Table 5).

The most effective strategies to increase

students' metacognitive knowledge are problem-based learning, reciprocal teaching and group investigation. Reciprocal teaching with mind mapping is more effective than with the usual note taking. Problem-based learning is most effective strategy in improving metacognitive knowledge since the strategy has several steps that correlate with metacognitive knowledge. Rahayu & Azizah (2012:167) stated that there are three phases and seven syntaxes of problem-based learning about metacognitive knowledge. Table 7 explains the relation of metacognitive knowledge, syntax and problem-based learning phases.

Another effective learning strategy is reciprocal teaching. Reciprocal teaching focuses neither on the discovery activity nor the knowled-

**Table 7.** The relation of metacognitive knowledge and problem-based learning syntax

Metacognitive knowledge	Syntax of Problem-based learning	Phase of Problem-based learning
Declarative knowledge	Exploring students' prior knowledge by having students to do Self-Understanding Assessment Question	Organize the student for study
	Asking students to collect all information related to the formulation of the problem in groups	
Procedural knowledge	Guiding students to observe/practice	Assist independent and group investigation
	Guiding students to do analysis and make conclusion to find explanations and solutions to the problem	
Declarative knowledge	Guiding students who have acquired the knowledge revealed from observations and analysis by asking the students do the Self-Understanding Assessment Questions and application question contained in the worksheet.	Analyze and evaluate the problem-solving process
	Guiding students to reflect or evaluate the learning process they use	
	Guiding students to conclude the learning outcomes (declarative,	

Source: Rahayu & Azizah (2012: 67)

ge construction. It focuses more on the reflection activities, i.e. questioning, clarifying, summarizing and predicting (Cooper & Greive, 2009:45). Agoro & Akinsola (2013:5) said that Reciprocal Teaching consists of the main component that describe metacognitive strategy. The component is the dialogue between an instructor and students where the instructor models why, when, and where to use the strategies. The practice of reciprocal teaching with mind mapping optimizes the students' metacognitive knowledge improvement. The application of mind mapping makes the information distributed on students' mind more structured as stated by Buzan (2012:8) mind map puts a new perspective on things by allowing you to see all the relevant issues and analyses choices in light of the big picture. Mind map also becomes easier to integrate new knowledge and organize information logically as you aren't tied to a rigid structure.

Furthermore, group investigation learning is the other effective strategy in improving metacognitive knowledge. Group investigation learning is discovery learning that gives students opportunities to construct knowledge in a group. Sharan & Sharan (1989:17) explained that in group investigation students take an active part in planning what they will study and how. All group members help plan how to research their topic. The discovery activity and knowledge construction in group investigation learning enable students to actively control their cognitive activities. The ability in utilizing cognitive activity control makes students' academic performan-

ce and achievement become higher (Jayaprabha & Kanmani, 1998:48).

## CONCLUSION

Problem based learning is one of the most effective strategies in improving metacognitive knowledge. Another strategy is reciprocal teaching with mind mapping. Meanwhile a group investigation is a strategy that is mostly practiced by teachers of Biology as it is literally effective to increase metacognitive knowledge.

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