JPII 5 (1) (2016) 1-5



Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# AN ANALYSIS OF STUDENTS' SKILL IN APPLYING THE PROBLEM SOLVING STRATEGY TO THE PHYSICS PROBLEM SETTLEMENT IN FACING AEC AS GLOBAL COMPETITION

## A. Halim<sup>\*</sup>, Yusrizal, Susanna, Tarmizi

Physics Education Study Program, the Faculty of Education, Universitas Syiah Kuala, Banda Aceh Darussalam, Indonesia

#### DOI: 10.15294/jpii.v5i1.5782

Accepted: 2 January 2016. Approved: 10 March 2016. Published: April 2016

#### ABSTRACT

The results of previous studies show that students of Physics Education (S1 and S2), FKIP Syiah Kuala University more than 50% do not understand the programs and roadmap of Pilar ASEAN Socio-Cultural Community as a part of the ASEAN Economic Community (AEC). The inference of those results to the implementation of learning physics and science education system needs to be implemented through a link and match learning model that can improve the ability to think critically and creatively, and students need to be trained to be problem solvers, not the problem makers.Based on these problems, through this research has been applied physics learning by using Problem Solving strategies on 25 students of Master of Physical Education and Science. At the end of the implementation study measured the ability of students to apply problem-solving strategies in accordance with Answer Sections of Problem Solving adopted from previous research. The results showed that the majority of students (78%) are able to implement the stage I (Focus on Problem) with a complete, almost all respondents (91%) was only able to implement the stage II (Describe the Physics) of about 40%, almost all respondents (91%) can apply for the stage III (Plan The Solution) approximately 80% of all respondents have been able to implement the stage IV (Excute the Plan) perfectly, and all respondents have been able to apply the stage V (Evaluate the Answer) completely. It is expected that all staff of teaching Science materials (Physics), they are recommended strongly to implement Problem Solving as an alternative strategy for preparing students to face global competition in the ASEAN Economic Community (AEC).

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: ASEAN Economic Problem Solving, Physics Education, Science Lesson

#### **INTRODUCTION**

The Society of Southeast Asian countries formed an organization in Bangkok on August 8, 1967, known as ASEAN. The main objective of thisinstitution is to create and maintain the security and peace in the region of Malaysia, Indonesia, Thailand, Singapore, and the Philippines. After 30 years later, or rather the establishment of ASEAN in 1997 goalsincerased to the economic sectors and social life, so in the end they come to an agreement to establish the ASEAN Econo-

\*Alamat korespondensi: Email: bdlhalim@yahoo.com mic Community (Hakim, 2013). The members of ASEAN Economic Community or shortened by the AECin 2003 in Bali, Indonesia had built the three main pillars, namely (i) the AEC (ASEAN Economic Community), (ii) the ASEAN Security Community and (iii) the ASEAN Socio-cultural Community (Arifin, 2007; 2008).

Roadmad pillar of Socio-Cultural Community (SCC) included in the educational, social and religious. Supposedly every learner, whether at low, medium and higher education levels must understand well what are Roadmad of the pillars of the ASEAN Socio-cultural Community (Halim et al., 2015). The main objective of the pillars are forming Human Resources (HR) in the ASEAN region to compete in the Southeast Asian region and also within the scope of International broadly. Therefore, for the success of the SCC ASEAN pillars implementation, at the higher level education learning model to adopt the link system and match through the learning model based on the ability to think critically and creatively, and students need to be trained to be problem solvers, not to be problem makers (Zamrozi, 2000; Wangke, 2014).

Problem Solving is one of the strategies to not only filled with a load of knowledge (Cognitive Load) (Sweller, 1988), but also regarding the technical or procedural (Bagno, 1997), and has a strong correlation with the leraners' structure of knowledge (Toth, 2009). In other words, learning activities Problem Solving strategies include cognitive and psychomotor domains (Frederiksen, 1984), as well as the realm of attitudes (Caballero et al, 2011). Some research indicates that through the implementation of strategies Troubleshooting formed two models of problem solving, the model expert (expert performance) and a model beginner (novice performance) (Larkin et al, 1980, 1980a; Schoenfeld, 1982; Kook, 1991). Besides, some of the results also showed that the implementation of Resolution Issues strategy is better done in a group than individuals (Heller et al, 1991), It needs cognitive skills, metacognitive skills, and motivational skills (Mayer, 1998), and can be developed representative metal (Savelsbergh, 1998). However, in the implementation of the Problem Solving strategy the solver intuitive are still affect both at the strategy starters stage (diSessa, 1993), or at the strategy undertaken stage done by experts (Sherin, 2005).

Despite the problems faced by the students in social life and culture is more complex, realtime, and various, it turns out that the students who have been trained and familiar with the strategy Problems Solving for physics problems in open-ended and unstructured forms (ill-structured) can easily be solved (Ogive, 2009). Results of other studies also show that students who have been trained to solve the problem of non-routine forms by multi-solution method is better than the students who are trained in methods of singlesolution (Lee et al, 2014; Bahar, 2015). Two of the latest research results as well as some previous research results give a strong recommendation that any problems that would be faced by the students in social and cultural life (Socio-culture Community), either in the form of close-ended (well-structured) or open-ended (ill- structured) will be resolved easily by the students who have

been trained and are familiar with problem solving strategies.

There are some attempts have been made in the higher education to face the global competition in the ASEAN Economic Community (AEC). Among the efforts to prevent the collapse of the culture and language through the preservation of local literature in the form of teaching materials (Sultoni, 2015), setting up of IT human resources with Scientific approach (Sholikha, 2015), to prepare the students to be entrepreneurial through the development of learning materials based on Life Skill (Khoiri et.al., 2011), to prepare the teachers who are able to compete and anti-corruption to include subjects of anti-Corruption in the syllabus LPTK (Murdani, 2014), and create a generation that mastered the technology through the provision of Basic Concepts of Science in Primary School students (Hidayah, 2014 ). As we know that we lack of data and informations how the efforts of higher education in preparing human resources who are able to compete globally in the AEC, through this study, it is possible to provide the students with the ability of accomplishing problems either closed-ended and open-ended.

#### **METHOD**

This research using Pre-Experimental Design approach in which the respondents were selected without going through random sampling and diagram for this design are shown in Table 1.

Table 1. Pre-Exp	perimental	Design
The One-Shot	Case Study	Design

X	0
Treatment	Observation
	(Dependent variable)

Source: (Fraenkel et.al., 2012).

The number of respondents involved in this study are 25 students of the Physical Education Master degree and Science. The treatments used at the first meeting is to stock the basic theory and practice to solve physics problems through Lecture and Discussion method (Kohl & Finkelstein, 2006). Respondents are also introduced and explained the rubric characteristics of physics problem solving assessment in the form of closed-ended or routine problems. While at the second meeting of the respondents were given two forms of assessment rubrics, they are; forms that have been filled (as a lecturer grip) and a blank form (for training the students).

For sections that have been filled, the res-

for each stage of the strategy to Troubleshooting. While for the blank rubric, the respondent was asked to be able to fill in the answers, according to the stages Troubleshooting strategy model (Heller et.al, 1991). The students' ability data to solve problems of physics are collected using a standard "Problem SolvingResponse Rubric" adopted from the research (Halim et al, 2010). Descriptive analysis of the answers are based on the completeness of student answers for every stage of Problem Solving strategies compared with standard stages which are carried out by an expert (the standart stages of Troubleshooting Strategy).

pondents were asked to give Grade on each item

#### **RESULTS AND DISCUSSION**

Overall results of the study are shown in Figure 1. The figure shown in comparison of completeness of respondents between each stage of Troubleshootingstrategy. The results discussion are discussed based on the stages of Problem Solving strategy.

#### Stage I (Focus on the Problem).

Based on the bar chart in Figure 1.1 above, it can be seen that the stage I (Focus on the Problem), most respondents (78%) can complete this stage completely (100%), but there is also a small proportion of respondents (22%) was only able to complete this stage of approximately 50%. Some of the relevant research results indicate that this stage (Focus on the Problem) on the strategy undertaken by beginners (Novice strategy) is invisible and difficult given the score compared with the strategy undertaken by experts (Heuvelen, 1991; Cock, 2012; Docktor, et .al, 2015).

The results of interviews with respondents showed that most of them (90%) in the stages before, has never been revealed in the form of visual or words, but only in the minds of the respondents, it is often called the "unwritten customs" in the problem-solving physics(Montague, et.al., 2000). But after the respondents were given theoretical and practical physics problem resolving the standard has increased very well at this stage.

#### Stage II (Describe the Problem)

This stage or a stagethat explain the problem in physics, is found only in the strategy of Problem Solving Problems of physics, which was designed by Heller in Tuminaro & Redish (2007), while the model Polya, which is widely used in mathematics, has four stages, not including this stage II (Xin et al, 2005). Most respondents (90%) was only able to fill 40% of the full answer in this second stage. In other words, many respondents who did not fill the solution in the second stage. One reason is that the respondent is uncommon or rarely taught the solution in the second stage, either at college or at the high school level. This is consistent with the findings made by Ibrahim & Robello (2013) of 19 engineering students who take kinematics course, none of which showed a visual depiction of metal in the form or expression in words.

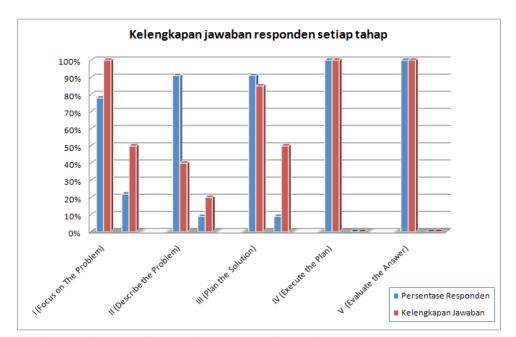


Figure 1. The Completeness of respondents Answer for each stage

#### Stage III (Plan the Solution)

The solutions activities in this stage, including measuring the ability of respondents to analyze the equation, compose what variables should be resolved first, checking the completeness of the information needed, whether it is necessary to form a new equation or not, and whether the units need to be converted or not. This kind of activity should be performed by the respondent. This fact is apparent from the results of the respondents in Figure 1. Approximately 90% of respondents were able to fill out a solution at this stage by about 80% complete. In the Problem Solving strategy practiced by beginners (Novice strategy) this stage can be completed perfectly (Schoenfeld, 1982).

#### Stage IV (Execute the Plan)

The capability of the respondents in this stage is good, where all respondents can fill the solutions at this stage perfectly. One reason is that this stage is the form of a solution that has been commonly done by the respondent to resolve the physics problems. The solution in this stage has no difference between the strategy undertaken by the beginners (Novice strategy) with the strategy undertaken by the Expert (Expert strategy) (Schoenfeld, 1982).

#### Stage V (Evaluate the Answer)

The ability of respondents at this stage is good, where all of the respondents can fill the solution at this stage perfectly. Although this stage is rarely done by the respondents formally, but after being given the concept and trained to solve the physics problems, the respondents could write the solution at this stage perfectly. The solution at this stage was not too difficult, the activity is just checking the numeric values, units and marks obtained (- or +).

#### CONCLUSION

The overall students (respondents) have been able to apply the right Problem Solving strategy, although the stage II (describe the problem) has not been done nicely. This is due to the respondents are not familiar with the contents of the requested solution in this stage. In the physics problem solving strategies, traditionally the respondents have never disclosed the solution as desired in stage II. The study results implications are expected to staff that administer the subjects of physics or science can develop an assessment rubric Problem Solving of a lecturer version and a student version. It certainly would make it easier to train students in implementing Problem Solvingstrategy as main ability to face global competition in the ASEAN Economic Community (AEC).

#### ACKNOWLEDGMENT

To all those who have helped this research activity, both in terms of materials, thoughts or ideas, we say many thanks. Especially to the managers and administrative personnel of Master of Science Education, Unsyiah specifically PPs, thank you very much for all your help.

#### REFERENCES

- Arifin, Sjamsul. (2008). Masyarakat Ekonomi ASEAN 2015; Memperkuat Sinergi ASEAN di Tengah Kompetisi Global. Jakarta; Elex Media Komputindo.
- Arifin, Syamsul, (2007). Integrasi Keuangan dan Moneter di Asia Timur; Peluang dan Tantangan Bagi Indonesia. Jakarta: Gramedia.
- Bagno, E. & Eylon, B.S. (1997). From problem solving to a knowledge structure: An examplefrom the domain of electromagnetism. *Am. J. Phys.*, 65(8), 726-736.
- Bahar, A. (2015). Cognitive Backgrounds of Problem Solving: A Comparison of Open-ended vs. Closed Mathematics Problems. *Eurasia Journal* of Mathematics, Science & Technology Education, 11(6), 1531-1546
- Caballero, A., Blanco, L.J. & Guerrero, E. (2011). Problem Solving and EmotionalEducation in Initial Primary Teacher Education. *Eurasia Journal of Mathematics, Science & Technology Edu cation*, 7(4), 281-292.
- Cock, D.M. (2012). Representation use and strategy choice in physics problem solving. *Physical Review Special Topics-Physics Education Research*. 8, 020117.
- diSessa, A.A. (1993). Toward an epistemology of physics. *Cognition and Instruction*, *10* (1), 165–255.
- Docktor, J.L., Strand, N.E., Mestre, J.P. & Ross, B.H. (2015). Conceptual problem solving in high school physics, *Physical Review Special Topics-Physics Education Research*. 11, 020106.
- Fraenkel, J.R., Wallen, N.E.& Hyun, H.H. (2012). How to Design and Evaluate Research and Education. McGrow Hill, New York.
- Frederiksen, N. (1984). Implications of Cognitive Theory for Instruction in Problem Solving, *Review* of Educational Research, 54(3), 363-407
- Hakim, M.Fathoni. (2013). ASEAN Community 2015 dan Tantangannya pada Pendidian Islam di Indonesia. *Laporan penelitian*,
- Halim, A, Susilawati& Melvina (2015) The understanding of physics education students about the ASEAN Sosio Cultural Community (ASCC) The International Seminar on The Asian Economic Community 2015, Palu, Indonesia.
- Halim, A., Halim, L., Meerah, S. &Kamisah, O.,

(2010). Pembangunan Instrumen Penyelesaian Masalah Sains, *Jurnal Pendidikan Malaysia*, *35*(1), 35-39.

- Heller, P., Keith, R. & Anderson, S. (1991). Teaching Problem Solving through Coorperative grouping. Part 1: Group versus Individual Problem Solving. Am.J.Phys, 60(7), 627-636.
- Heuvelen, A.V. (1991). Learning to think like a physicict: A review of research-based instructional strategies. *Am.J.Phys.*, 59(10), 891-897.
- Hidayah, P. (2014). Pentingnya Pendidikan Dasar Sains pada Jenjang Pendidikan SD/MI dalam rangka Mengejar Kemajuan Teknologi. *Al-Bidayah*, 6(2), 273-289.
- Ibrahim, B. & Rebello, S. (2013). Role of mental representations in problem solving: Students' approaches to nondirected tasks. *Physical Review Special Topics-Physics Education Research*. 9, 020106.
- Khoiri, N., Hindarto, N. & Sulhadi. (2011). Pengembangan Perangkat Pembelajaran Fisika Berbasis Life Skill untuk meningkatkan Minat Kewirausahaan Siswa. Jurnal Pendidikan Fisika Indonesia, 7 (1), 84-88.
- Kohl, P.B., & Finkelstein, N.D. (2006). Effect of representative on students solving physics problem; A fine-grained characterization. *Physical Review Special Topics-Physics Education Research*. 2, 010106.
- Kook, A.J. (1991). Representation of Models for Expert Problem Solving in Physics. *IEEE Transactions on Knowledge and Data Engineering*, 3(1), 48-54.
- Larkin, J.H., McDermott, J., Simon, D.P., & Simon, H.A. (1980a). Models of Competencein Solving Physics Problems. *Cognitive Science*, 4 (1), 317-345.
- Larkin, J.H., McDermott, J., Simon, D.P. & Simon, H.A. (1980). Expert and Novice Performance in Solving Physics Problem. *Science*. 208 (1), 1335-1342.
- Lee, C.Y., Chen, M.J.& Chang, W.L. (2014). Effects of the Multiple Solutions and Question Prompts on Generalization and Justification for Non-Routine Mathematical Problem Solving in a Computer Game Context. *Eurasia Journal of Mathematics, Science & Technology Education*, 10(2), 89-99
- Mayer, R., (1998). Cognitive, metacognitive, and motivational aspects of problemsolving, *Instructional Science* 26 (1), 49–63
- Montague, M., Warge, C. & Morgan, T.H. (2000). Solve It! Strategy Instruction to Improve Math-

ematical Problem Solving, *Learning Disabilities Research & Practice*, 15(2), 110-116.

- Murdani, E. (2014). Pendidikan Indonesia dalam Rangka Menghadapi ASEAN Community 2015. Proseding Seminar Bisnis & Teknologi, IBI DARMAJAYA 15-16 Desember 2014.
- Ogive, C.A. (2009). Changes in students' problem-solving strategies in a course that includes contextrich, multifaceted problems. *Physical Review Special Topics, Physics Education Research*, 5.
- Savelsbergh, E.R. (1998). Improving Mental Representation in Pkysics Problem Solving, *Dissertation* of *Ph.D Program*. Twente University of Amsterdam. Berlijn.
- Schoenfeld, Alan, H. (1982). Expert and Novice Mathematical Problem Solving. *Journal for Research in Mathematics Education*, 13(1), 31-49.
- Sherin, B. (2005). Common Sense Clarified: The Role of Intuitive Knowledge in Physics Problem Solving, *Journal of Research in Science Teaching*, 43(6), 353-555.
- Sholikha, S.M. (2015). Penerapan Teknologi Informasi dalam Pendekatan Saintifik pada Mata Pelajaran Ekonomi. *Prosiding Seminar Nasional 9 Mei* 2011, Surabaya.
- Sultoni, A. & Hilmi, H.S. (2015).Pembelajaran Sastra Berbasis Kearifan LokalSebagai Upaya Optimalisasi Pendidikan Karakter KebangsaanMenuju Masyarakat Ekonomi ASEAN (MEA). Prosiding Seminar Nasional Pendidikan Bahasa Indonesia 2015. Surakarta.
- Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning, *Cognitive Science*, 12 (1),257-285.
- Toth, Z. & Sebestyen, A. (2009). Relationship between Students' Knowledge Structure and Problem-Solving Strategy in Stoichiometric Problems based on the Chemical Equation. *Eurasian J. Phys. Chem. Educ.*, 1(1), 8-20.
- Tuminaro, J. & Redish, E.F. (2007). Elements of a cognitive model of physics problem solving: Epistemic games. *Physical Review Special Topics-Physics Education Research*. 3.
- Wangke. H. (2014). Peluang Indonesia dalam Masyarakat Ekonomi ASEAN 2015, *Majalah Info Singkat*, Vol. VI, No. 10/I/P3DI/Mei/2014.
- Xin, Y.P., Jitendra, A.K. & Buchman, A.D. (2005). Effects of Mathematical Word Problem–Solving Instruction on Middle School Students with Learning Problems. *The Journal of Special Education*, 39(3), 181-192.
- Zamrozi, (2000). Paradigma Pendidikan di Masa Depan, Yogyakarta; Bayu Indra Grafika.





Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

## THE STUDY OF MENTAL MODEL ON N-HEXANE-METHANOL BINARY SYSTEM (THE VALIDATION OF PHYSICAL CHEMISTRY PRACTICUM PROCEDURE)

## Albaiti<sup>1</sup> Liliasari<sup>2</sup>, Omay Sumarna<sup>3</sup>

<sup>1</sup>Universitas Cendrawasih, <sup>2, 3</sup>Universitas Pendidikan Indonesia, Indonesia

#### DOI: 10.15294/jpii.v5i1.5783

Accepted: 4 January 2015. Approved: 14 March 2016. Published: April 2016

#### ABSTRACT

N-hexane and methanol systen is one example of a binary system that shows the solubility properties of reciprocity. This study aimed to assess the mental model of a n-hexane-methanolbinary system. Interaction at the submicroscopic level between n-hexane and methanol molecules is described in the form of mental model. Penelitian ini menggunakan cloud point method untuk memperoleh data kesetimbangan cair-cair sistem n-heksana-metanol. This study used a cloud point method to obtain data on liquid-liquid equilibrium on the system of n-hexane-methanol. Research data showed the maximum critical temperature (above the consolute temperature) of this system was at 42.95 °C with Xmethanol = 0.475 (P= 715 mmHg). Data from the laboratory observations was represented as a symbolic level in the form of the curve of correlation between mole fraction of methanol with temperature in a phase diagram system of n-hexane-methanol. The curve that was formed was asymmetric. It indicated that the solubility of n-hexane in methanol was relatively small compared to the solubility of methanol in n-hexane. Mental model of the binary system of n-hexane-methanol in four curve areasin the form of visualization of the interaction between n-hexane and methanol molecules through London force. In thermodynamics, each component had the same chemical potential inboth phases at equilibrium state. This study results could have a contribution to form a mental model on the student as the prospective chemistry subject teachers.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: n-hexane-methanol system; mental model, macroscopic level; submicroscopic level; symbolic level.

## INTRODUCTION

Physical chemistry is defined as the study of which is based on the principles of physics and mathematics terms that determines the properties and behavior of chemical systems. The physical chemistry could be investigated at the level of macroscopic, submicroscopic and symbolic. By studying the material of physical chemistry that refers to the phenomena observed (macroscopic), chemistry students can explain the phenomenon through submicroscopic explanation. The explanation at the submicroscopic level is strongly supports the symbolic explanation in the form of a derivative formula or a formula obtained from the

\*Alamat korespondensi: Email: baityjabarmase@gmail.com observed phenomena. In principle, the students need to associate the phenomenon of macroscopic, submicroscopic and symbolic in studying the material of physical chemistry. It is intended that the students as the teacher candidates must fullyunderstand the chemistry, since they have to deliver it to their students in the future.

In order to achieve the goal of chemistry fully understanding, the scientists present the concept into three levels of representation to explain the chemical phenomena. First, the macroscopic level as the level that is consistent with the observation of concrete objects. At this level, the students observe the chemical phenomena in the experiment. Second, the submicroscopic level as an abstract level; however, it is related to a phenomenon that can be observed at the macroscopic level. This level is characterized by concepts, theories and principles used to explain what is observed at the macroscopic level, using things like the movement of electrons, molecules, atoms, or ions. Third, the symbolic level that is used to describe chemical reactions and macroscopic phenomena using chemical equations, mathematical equations, graphs, reaction mechanism, analogies, and certain models (Jansoon et al., 2009).

Chittleborough (2004) presented that the students' ability to understand and to decipher the chemistry representation reflects the level of their mental models. Greca and Moreira (in Wang & Barrow, 2010) described the mental models as an internal representation constructed by a person to understand or to give a rational explanation of a phenomenon of experience. Mental models are used to produce a simpler concept, providing support for the simulation and visualization, as well as providing explanations for scientific phenomena (Coll, 2009).

The results of research by Nyachwaya & Wood (2014) showed that most physical chemistry textbooks omit discussion of how to link the mathematical representations to the macroscopic level or submicroscopic level. The use of multiple representations to associate the macroscopic level with submicroscopic level and symbolic level is very limited, not more than 1% of the overall pictures in the textbook. It is also found in the laboratory component in the physical chemistry lecture. The lack of use of this multiple representations certainly impacts the formation of student mental models.

Phase equilibrium is one of the study materials in physical chemistry lecture. The results of the previous studies indicated that there has been a student misunderstanding about the concept of vapor pressure equilibrium, phase diagrams, phase changes, colligative properties and Rault's law (Azizoglu et al., 2006). Also, there have been the misinterpretation on the concept of evaporation and vapor pressure (Conpolat et al., 2006) and misconceptions on the concept of evaporation, condensation and vapor pressure (Gopal et al., 2004).

Binary system is one of the topics of phase equilibrium in the physical chemistry lecture that is studied by the students of chemistry teacher candidates. To date, the research on the topic of binary systems is only focus to examine the behavior of binary systems in the laboratory (Dai & Chao, 1985; Alessi et al, 1989). There are no studies which evaluating the binary system by linking the three levels of the chemical representation. System of n-hexane and methanol is one example of a binary system which shows the solubility properties of reciprocity as the focus of this study. The interaction that occurs in the system of n-hexane-methanol at a submicroscopic level is depicted in the form of mental models. This study aimed to assess the further mental model of the binary system of n-hexane-methanol. This study was intended to contribute the formation of a mental model of the student of chemistry teacher candidates.

#### **METHODS**

This study was a validation of the binary system practicum procedure by using the cloud point method. The tools used in this study were test tubes, corks as the tube plug, beakers, hot plate with a magnetic stirrer, the stand and clamp, thermometers, measuring pipettes and the ball respirators. Materials used to support the system were n-hexane and methanol (Pro-Analysis Grade).

The temperature of the water bath used was set at  $\pm$  55 °C to prevent the fast evaporation process of methanol. Methanol in amount of 0.1 ml (± 2 drops) was incorporated into 5 ml nhexane in a test tube. When the obtained solution was not cloudy, the solution was then added back by 0.1 ml of methanol. But if the solution turned cloudy, the reaction tube was closed using the cork. The test tube was then heated along with its contents in the bath while stirring. The temperature of the mixture was recorded exactly when the mixture turned from cloudy to clear  $(T_1)$ . The test tube was removed from the water bath, and then it was allowed to stand while stirring until cool. The temperature of the mixture was also recorded at the time of cloudy was appearing  $(T_2)$ . Based on this data, the mean temperature (T) was calculated and was accounted. These steps were repeated for several times.Data obtained from the optimization of n-hexane and methanol system lab procedures was subsequently assessed descriptively by explaining in the submicroscopic and symbolic level.

#### **RESULTS AND DISCUSSION**

The study was conducted at 715 mmHg air pressure. Table 1 represents the information about the physical and chemical properties of substances.

The results obtained from the addition of a certain amount of methanol into a 5 ml n-hexane are presented in Table 2.

Table 1. Density, molar mass, and boiling point of n-hexane and methanol

Substance	Density (g/ml)	Molar mass (g/mol)	Boiling point (°C)
n-hexane	0.660	86.18	69.0
Methanol	0.792	32.04	64.7

**Table 2.** Temperature of the mixture of 5 ml n-hexane with methanol addition

Volume of methanol (ml)	Average temperature (T) (°C)	Methanol mass (gram)	N-hexane mass (gram)	Mole Fraction of methanol	Mole fraction of n-hexane
0.1	Clear solution	(methanol was d	issolved in n-he	exane) at 26°C	
0.2	Clear solution	(methanol was d	issolved in n-he	exane) at 26°C	
0.3	Clear solution	(methanol was d	issolved in n-he	exane) at 26°C	
0.4	32.70	0.2640	3.3	0.177	0.823
0.6	38.10	0.4752	3.3	0.279	0.721
1.0	41.55	0.7920	3.3	0.392	0.608
1.1	42.15	0.8712	3.3	0.415	0.585
1.2	42.45	0.9504	3.3	0.436	0.564
1.3	42.85	1.0296	3.3	0.456	0.334
1.4	42.95	1.1088	3.3	0.475	0.525
1.5	42.80	1.1880	3.3	0.492	0.508
2.0	41.95	1.5840	3.3	0.564	0.436
3.0	39.30	2.3760	3.3	0.660	0.340
5.0	33.90	3.9600	3.3	0.763	0.237

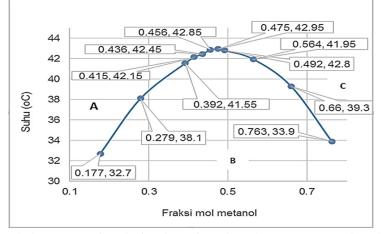


Figure 1. The correlation curve of mole fraction of methanol to temperature in n-hexane-methanol phase diagram.

#### Diagram of n-hexane and methanol system

Based on the data in Table 2, the curve in phase diagram of the interaction between methanol mole fraction with temperature could be constructed (Figure 1).

Based on Figure 1, the asymmetricalshapedcurve (tend to skew to the right) shows the solubility of n-hexane in methanol that is relatively small compared to the solubility of methanol in n-hexane. This is due to the solubility of a substance that is also influenced by the size of the solute hydrocarbon chain. The longer the hydrocarbon chain, the smaller the solubility of the solute. Continuous chain molecules such as nhexane open chain, can straighten the molecules according to the chain winding (zig-zag), which allows the atoms of the molecules occupy a position that corresponds to the radius of van der Waals. Maximum towing of van der Waals arises between the molecules of n-hexane. Therefore, more energy is needed to overcome the van der Waals towing between molecules of n-hexane resulted in the smaller solubility (Fessenden & Fessenden, 1986).

Based on Figure 1, methanol and n-hexane can dissolve each other at any given composition when the system temperature was above 42.95 °C. This temperature is called as the maximum critical temperature (consolute temperature) of the n-hexane-methanol system with  $X_{metanol}$  = 0.475 (P = 715 mmHg). The obtained maximum critical temperature was closed to the results obtained in Rothmund (in Alessi et al, 1989) that was equal to 43.5 °C. However, these results were not consistent with the results obtained by Alessi et al (1989) that was equal 35.15 °C. The differences in the results obtained were thought to be caused by the presence of water in methanol (purity level of methanol). This study used methanol with a density of 0.792 g/ml. According to the results of the research of Alessi et al (1989) about the density of methanol-water system as a function of the mole fraction of water at 298.15 K; it showed a mole fraction of the water with a density of methanol amounted to 0.792 g/ml around 0.0349. Meanwhile, the methanol used by Alessi et al, (1989) had a density of 0.786846 g/ml and showed 99.9% purity of methanol. Thus, the presence of water in methanol could affect the data of liquid-liquid equilibrium of the n-hexane-methanol binary system obtained.

#### Mental model of n-hexane-methanol system

The submicroscopic level visualization of the interaction that occured in the n-hexane and methanol mixture is presented in Figure 2. Single-phase of N-hexane-methanol system (region A)

Methanol is a polar substance that is polar (dipole moment 1.69 D) while the n-hexane is a non-polar substance (dipole moment 0.08 D). Between the methanol molecules, there is an interaction in the form of hydrogen bonds. Meanwhile, the interaction between molecules of n-hexane occurs through London force. Molecularly, the hydrogen bond is stronger than the London force.

When methanol is added to the n-hexane. London force between then-hexane molecules and the hydrogen bonds between the methanol molecules will be disconnected. A new interaction between n-hexane and methanol will be formed. However, the new interaction formed is different with the previous interaction. The energy required to break the hydrogen bonds is greater than the energy needed to alter the London force. Methanol molecules must compensate for losing some of the hydrogen bonds and the formation of a weak interaction between n-hexane and methanol with new form of hydrogen bonds in a new setting. The interaction in the system after mixing n-hexane with methanol is proportional to the strength of the interaction of each substance in a separate state. For this reason, a small amount of energy is absorbed when a small amount of methanol can be dissolved in n-hexane, or vice versa.

The low solubility of methanol in n-hexane or vice versa can be explained by the change in the entropy of the system. When n-hexane is mixed with methanol, the particles formed by the new arrangement shows the lower entropy of system than the entropy of each fluid (methanol and n-hexane) in a separate state. Naturally, there is a tendency toward entropy methanol and n-hexane in a separate state (higher entropy of the system); therefore, both the liquid is difficult to mix (so-

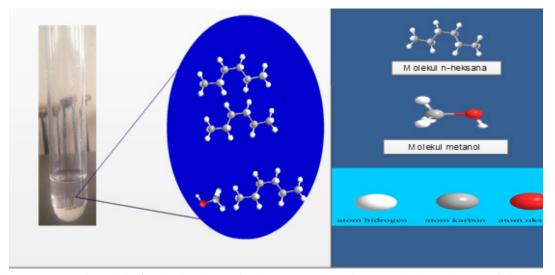


Figure 2. Mental model of a single-phase of n-hexane-methanol system in the region A of the curve

lution becomes cloudy and form a two-phase). Possible interaction between the molecules of nhexane and methanol molecules is London force. The hydrogen atoms of the methyl group (hydrocarbon) in methanol molecules will interact with hydrogen atoms from n-hexane molecules. In addition, the region A of this curve shows an interaction between the n-hexane molecules in the form of London force, the interaction is visualized in Figure 2.

### Single-phase of n-hexane-methanol system (region C)

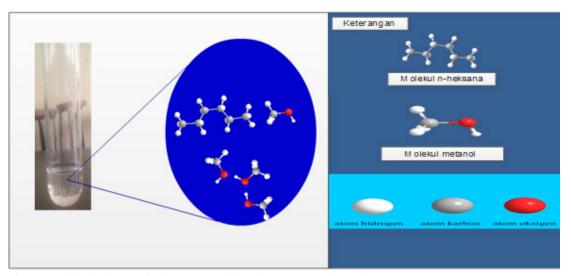
The relationship curve between temperatures with n-hexane-methanol composition showed that the region C is the area of a single-phase. It means that there is a dissolution process when adding a certain amount of n-hexane into methanol at a certain temperature and air pressure at 715 mmHg. Figure 3 shows the methanol molecules can bind to the molecules of n-hexane through London force. Meanwhile, among other methanol molecules is formed the hydrogen bonds. *The addition of 1.5 ml methanol into 5 ml n-hexane to form a two-phase (region B)* 

Mixing 1.5 ml methanol into 5 ml n-hexane produced a two-phase (two layers). This result showed shows the limitation of solubility of methanol in n-hexane. According to the density of both substances, the majority of n-hexane was on the top layer, while the majority of the methanol was in the bottom layer. Figure 4 shows the interaction of London force between methanol and nhexane molecules and the interaction of London force between n-hexane molecules at layer 1 (the top layer). Meanwhile, at layer 2 (bottom layer), the interaction between n-hexane molecules is in the form of London forces and the interactions between methanol molecules is in the form through hydrogen bonds.

# *N-hexane-methanol system in a single-phase above the curve*

Increasing of the system temperature until it reached a critical temperature could accelerate the process of methanol dissolution in n-hexane. This was because of the great thermal movement resulted in greater mixing capabilities in both components. The increasing of the system temperature resulted in a number of energy absorbed by the system altered the interactions (the intermolecular attractive force), which acted between n-hexane and methanol molecules. The entropy of the system was increased. As a result, the mixing ability of the two substances was greater. The mixing of methanol and n-hexane above the maximum critical temperature resulted in the nhexane-methanol dissolution process could take place in any composition. Figure 5 is an example of the interaction between n-hexane and methanol molecules through London forces in addition to the interaction between n-hexane molecules through London force as well.

The phase formula of n-hexane-methanol system at a constant pressure is f = c-p + 1. The degrees of freedom (f) for the region in two phases (region B in the curve), which consists of two components, namely the n-hexane and methanol is f = 1. It only needs one variable to declare a state of the system in this region. If the selected variable is the temperature of the system, then the tie line with the curve of the second composition resulting in a conjugate solution (methanol in n-hexane and n-hexane in methanol). If the selected variable is the composition of a solution of the conjugate, then the system temperature and the other solution composition can be determined. Meanwhile, the degrees of freedom for the region of the phase (regions A and C on the



**Figure 3.** Single-phase of n-hexane-methanol system (region C)

curve and the region above the curve) is f = 2. It is indicated that it takes two variables to declare a state of the system in this area. If the selected variable is the composition of a conjugate solution and the system temperature then other conjugate composition of the solution can be determined.

#### The overview of standpoint of thermodynamics (chemical potential) phase equilibrium of the n-hexane and methanol system

Macroscopically, we can observe only two possibilities when the two liquids are mixed, i.e. a single-phase or a two-phase. The first possibility occurs when the solubility of the first liquid in the second liquid has not been exceeded. The second possibility occurs when the solubility of one of the liquids are exceeded and hence will occur in two phases, each of which is a saturated solution. Both possibilities can be explained from the standpoint of thermodynamics than the explanation on the submicroscopic level with respect to the intermolecular attractive forces that have been described previously. When methanol is dissolved in n-hexane, then methanol in the chemical potential of the solution can be expressed as . is the chemical potential of methanol in a pure state, whereas is the mole fraction of methanol in the solution with the assumption of an ideal solution. If the chemical potential of methanol in n-hexane is lower than the chemical potential in a state of pure methanol, the dissolution process may still be ongoing. However, after the leaching process is beyond the point, the chemical potential of methanol in the solution is greater than the chemical potential in a state of pure methanol; the methanol transfer will occur to the outside of the solution entering the pure methanol phase and eventually reach the equilibrium state.

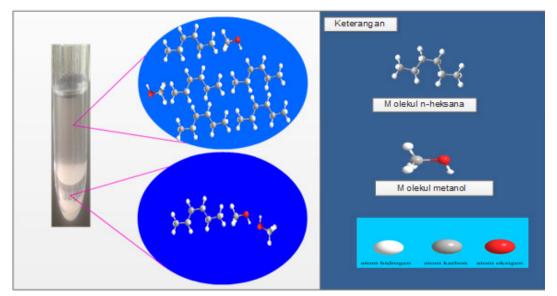


Figure 4. Mental model of a two-phase of n-hexane-methanol system in the región B of the curve

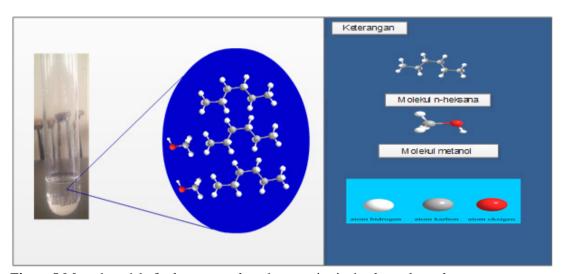


Figure 5. Mental model of n-hexane-methanol system in single-phase above the curve

This explanation can also be applied to explain the second component is n-hexane. If the chemical potential of n-hexane in the solution is lower than the chemical potential of pure n-hexane, then the dissolution process of n-hexane in methanol is still ongoing. However, if a potential chemical of n-hexane in the solution is greater than the potential of n-hexane in a state of pure, then the displacement components of n-hexane out of solution will be occurred and entering into the pure phase of n-hexane. After reaching the equilibrium state, both saturated solution, i.e. methanol in n-hexane and n-hexane in methanol are called conjugate solution. Thus, the two phases are in equilibrium; therefore, there are no one of two phases is in a pure substances phase. At equilibrium (area B on the curve), the chemical potential of each component in the phase are the same. Suppose that the first phase is symbolized by  $\alpha$  and the second phase is symbolized by the  $\beta$ then it can be expressed as (Alberty & Daniels, 1981).

Overall, the mental model of this binary system describes the interactions that occur at the submicroscopic level of mixing n-hexane and methanol according to the definition of mental models that are synthesized from the opinion of some experts. Mental model is an internal representation of cognitive constructed by someone; include a visual-pictorial component and propositional components to understand or to give a rational explanation of a real-world phenomenon or imaginary situations, events, or processes. The structure reflects the structure of which can be felt (perceived structure) on those situations, events or processes (Schnotz & Bannert in Wang & Barrow, 2010); Nersessian in Tumay, 2014).

This binary system study showed that nhexane and methanol can be mixed at a certain temperature and composition. The macroscopic phenomenon of n-hexane and methanol mixing in four areas of system curve can be explained in submicroscopic level regarding to the interactions that occur in the system. Tversky in Akaygun & Jones (2013) stated that the image is an effective cognitive tool when it used as a concrete and meaningful representation. It is more effective compared to the written language. On the other hand, written language is more effective to communicate and to deliver the abstract concepts, causality and quantification. It is difficult to illustrate these concepts in pictorial. The findings in this study were able to accommodate these two ideas. The phenomenon of binary system of nhexane-methanol was described by using visualization and verbal explanation.

The concept of polarity and intermolecular towing force is a pre-requisite concept that students must master it in order to explain the submicroscopic level of observed binary system phenomena. In addition, the concepts of thermodynamics (e.g. chemical potential and entropy) are required to describe the symbolic level of observed binary system phenomena. On the other hand, the results of the research on atomic structure, periodic system of elements, chemical bonding, molecular geometry and polarity shows the quality of the students on explaining the material of study in these topics were varied from high to low abilities, in line with their ability to reconcile the new information into the frame of existing knowledge (Wang & Barrow, 2013). Students have the alternative conceptions of intermolecular and intramolecular towing forces (Sendur, 2014). In addition, the results of an investigation of 34 students with varying alternative conceptions about chemical thermodynamics indicated that this material was not easy to learn because it is too abstract (Sreenivasulu & Subramaniam, 2013).

In summary, the study of the mental model of n-hexane-methanol binary system was very useful to the formation of mental model and it increased the understanding of the student of chemistry teacher candidate. The ability to construct and to use the mental models could affect the conceptualization of students about the chemistry concepts on the topic of the binary system. In line with the opinion of Wang & Barrow (2010) who stated that the student of teacher candidates were needed to be encouraged to use mental model as a tool for linking the three levels of chemical representation when inserting knowledge into long-term memory (Devetak, Vogrinc & Glazar in Jansoon et al., 2009). According to this result, in order to support the efforts to develop a basic understanding of chemistry concepts, the learners should be able to associate their understanding in the level of symbolic to the level of macroscopic and the level of submicroscopic (Bain et al., 2014; Hernandez et al., 2014). It certainly needs to be supported by the pattern of teaching facilities which are useful for generating discussion connectedness between levels of representation (Becker et al., 2015).

#### **CONCLUSION**

The study of mental model of n-hexanemethanol binary system could be in the form of visualization of intermolecular interactions that occur between n-hexane and methanol through London forces; also in the form of intermolecular interactions between methanol through hydrogen bonds and intermolecular interactions of nhexane through London force. Mental model of the system was described in the four areas curve of methanol mole fraction to the temperature in a phase diagram of n-hexane-methanol system. Based on the curve of the system phase diagram, methanol and n-hexane could dissolve each other at any given composition when the system temperature was above 42.95 °C. This temperature was called as the maximum critical temperature (above consolute temperature) of n-hexane-methanol system. The results of the mental model study of n-hexane-methanol binary system can be followed up by developing a learning model of binary systems to improve the mental model and the student understanding.

#### REFERENCES

- Akaygun, S. & Jones, L. L. (2013). Words Or Pictures : A Comparison of Written and Pictorial Explanations of Physical and Chemical Equilibria. *International Journal of Science Educations*, 36(5), 783-807.
- Alberty, R. A. & Daniels, F. (1981). *Kimia Fisika*. Edisi Ketujuh. Jilid 1. Jakarta : Erlangga.
- Alessi, P., Fermeglia, M. & Kikic, E. (1989). Liquid-Liquid Equilibrium of Cyclohexane-n-Hexane-Methanol Mixtures: Effect of Water Content. *Journal of Chemical and Engineering Data*, 34(2), 236-240.
- Azizoglu, N., Alkan, M. & Geban, O. (2006). Undergraduate Pre-Service Teachers' Understanding of Phase Equilibrium. *Journal of Chemical Education*, 83(6), 947-953.
- Bain K., Moon A., Mack M. R. and Towns M. H. (2014). A Review of Research on the Teaching and Learning of Thermodynamics at the University Level. *Chemistry Education Research and Practice*, 15(1), 320–335.
- Becker, N., Stanford, C., Towns, M. & Cole, R. (2015). Translating Across Macroscopic, and Symbolic Levels : The Role of Instructor Facilitation in an Inquiry-Oriented Physical Chemistry Class. *Chemistry Education Research and Practice, 16*(1), 769-785.
- Chittleborough, G. D. (2004). The Role of Teaching Models and Chemical Representation in Developing Studdents' Mental Models of Chemical Phenomena. Disertasi. Perth :Curtin University of Technology.
- Coll, R, K. (2009). Do Gifted Students View and Use

Mental Models Differently from Others?. *Educacion Quimica, 1*(1), 18-31.

- Conpolat, N., Pinarbasi, T., & Sozbilir, M. (2006). Prospective Teachers' Misconceptions of Vaporization and Vapour Pressure. *Journal of Chemi*cal Education, 83(8), 1237-1242.
- Dai, M., & Chao, J. P. (1985). Heats of Mixing of Partially Miscible Liquid System Cyclohexane + Methanol. *Fluid Phase Equilibria*,23(1), 315-319.
- Fessenden, R. J. & Fessenden, J. S. (1986).*Kimia Organik*. Edisi ketiga, Jilid 1.Jakarta : Erlangga.
- Gopal, H., Kleinsmidt, J., Case, J. & Musonge, P. (2004). An Investigation of Chemical Engineering Students' Understanding of Phase Change. *International Journal of Science Education. 26*(13), 1597-1620.
- Hernandez, G. E, Criswell, B. A., Kirk, N. J., Sauder, D. G. & Rushton, G. T. (2014). Pushing for Particulate Level Models of Adiabatic and Isothermal Processes in Upper-Level Chemistry Courses : A Qualitative Study. *Chemistry Education Research and Practice*, 15(1), 354-365.
- Jansoon, N., Coll, R. K., & Somsook, E. (2009). Understanding Mental Models of Dilution in Thai Students. *International Journal of Environmental* & Science Education, 4(2), 147-168.
- Nyachwaya, J. M., & Wood, N. B. (2014). Evaluation of Chemical Representations in Physical Chemistry Textbooks. *Chemistry Educatio Re*search and Practice, 15(1), 720-728.
- Sendur, G. (2014). Are Creative Comparisons Developed by Prospective Chemistry Teachers Evidence of Their Conceptual Understanding? The Case of Inter- and Intramolecular Forces. *Chemistry Education Research an Practice*, 15(1), 689-719.
- Sreenivasulu, B. & Subramaniam, R. (2013). University Students' Understanding of Chemical Thermodynamics. *International Journal of Science Education*, 35(4), 601-635.
- Tumay, H. (2014). Prospective Chemistry Teachers' Mental Models of Vapor Pressure. *Chemical Education Research and Practice*, 15(1), 366-379.
- Wang, C.Y., & Barrow, L.H. (2010). Characteristics and Levels of Sophistication : An Analysis of Chemistry Students' Ability to Think with Mental Models. *Research Science Education*, 41(1),561-586.
- Wang, C. Y. & Barrow, L. H. (2013). Exploring Conceptual Frameworks of Models of Atomic Structures and Periodic Variations, Chemical Bonding, and Molecular Shape and Polarity : A Comparison of Undergraduate General Chemistry Students with High and Low Levels of Content Knowledge. *Chemistry Education Research and Practice*, 14(1), 130-146.

JPII 5 (1) (2016) 14-21



Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# THE DIAGNOSIS OF SENIOR HIGH SCHOOL CLASS X MIA B STUDENTS MISCONCEPTIONS ABOUT HYDROSTATIC PRESSURE CONCEPT USING THREE-TIER

## C. P. Wijaya\*, Supriyono Koes H., Muhardjito

Universitas Negeri Malang, Indonesia, Indonesia

#### DOI: 10.15294/jpii.v5i1.5784

Accepted: 2 January 2016. Approved: 22 March 2016. Published: April 2016

#### ABSTRACT

One of the main problems in physics is the emergence of students' misconceptions which comes from the prejudices of false starts and a naive belief. Many studies have shown that students tend to have developed their own understanding before the formal teaching is done. The ideas which are developed by students which are different from the explanations by the experts are known as misconceptions. The initial idea that has been formed by the students is very difficult to change by the teachers although the materials are presented with scientific concepts. Misconceptions diagnosis research on the hydrostatic pressure concept was conducted on 23 students of class X MIA B SMAN 3 Malang using Three-tier test. The diagnosis results that the students get misconceptions on the indicators, it explain the hydrostatic pressure is influenced by the depth and at all points located in the horizon-tal area in the calm liquid has the same hydrostatic pressure is greater at a point closer to the closed cavity (43.5%), 2) the students believe that the hydrostatic pressure is greater on the outside of the cave because it has a larger volume of fluid so that the pressure is higher (17.4%), 4) students had misconceptions in determining the depth in case of hydrostatic pressure (13%), 5) the students believe that the hydrostatic pressure is greater is greater in the narrow place (13%).

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: Hydrostatic Preassure, Misconceptions, Three-tier.

#### INTRODUCTION

One of the main problems in physics is the emergence of students' misconceptions which comes from the prejudices of false starts and a naive belief. Students develop ideas about how things work based on their experience (Driver, 1994). Many studies have shown that students tend to have developed their understanding before the formal teaching is done (Halim et al., 2014). The ideas are developed by the students are different from the explanations by the experts; this is a misconception (Chamber & Andre, 1997; Hammer 1996; Lawson, 1995; Yalcin, 2008). The initial idea that has been

Email: wijaya.charisma.pramuda@gmail.com

formed by the students is very difficult to change by teachers although presented with scientific concepts (Tsai, 1999; Sencar & Eryilmaz, 2004). The students' misconceptions in physics initially be derived from many sources, among others: their interaction with daily life, textbooks, reference books, teachers, languages, beliefs, and cultural practices (Ivowi & Uludotun, 1987; Soyinbo, 1993). Therefore, the teachers should identify the students' misconceptions before making a formal teaching so those misconceptions can be altered to scientific concepts after the formal teaching and learning process (Wong & Solomon, 2008).

The materials in physics are still full of misconceptions, one of them can be found on the hydrostatic pressure material. From a research

<sup>\*</sup>Alamat korespondensi:

conducted by Pratiwi & Wasis (2013) mentions that the students had misconceptions such as: 1) the magnitude of the pressure is influenced by the broadness of the container, 2) the density of water is less than the density of the oil because they have the same volume and height, 3) the magnitude of the pressure is determined by the broadness of the container, volume, and mass of the substance. Research conducted by Goszewski et al. (2012) also mentions the hydrostatic pressure of the material misconception: 1) the errors in the determination of h or depth, 2) the errors in determining the hydrostatic pressure which have three holes. Based on these results the researchers get a source of misconceptions in the hydrostatic pressure material generally in the determination of the depth (h), so in the future researchers will focus on the concept and other concepts are still likely to be considered as potential misconceptions.

A number of ways can be used to diagnose the misconceptions that occur in students. These ways may in the form of interviews (Atwood and Atwood, 1997), questionnaire (Stover & Saunders, 2004), open-ended question (Küçüközer, 2007), multiple choice test (Tsai & Chou, 2002; Trumper, 2003; Brunsell & Marcks, 2005), Two-tier test (Franklin, 1992; Tan et al., 2002; 2005) and Three-tier test (Eryilmaz, 2010; Eryilmaz & Surmeli, 2002; Pesman & Eryilmaz 2010; Arslan et al., 2012 ; Caleon, et al., 2010). One of the ways used in the misconceptions diagnosis is using three-tier diagnostic test. Three-tier diagnostic test is a diagnostic test that is composed of three tiers questions. The first level (one-tier) is a regular multiple choice, the second level (twotier) in the form of a choice of reasons, and the third level (three-tier) in the form of questions affirmation from the answers that have been made on the level one and two (Kirbulut, 2014; Kutluay, 2005; Turker, 2005). The Three-tier diagnostic test has several advantages: 1) makes it possible to calculate the percentage of positively incorrect and negatively incorrect without conducting interviews with the students, which can be used to determine the validity of the tests (Perman & Eryilmaz, 2010), 2), evaluate the misconceptions, understand the reasons given by the students, and to distinguish the students' lack of knowledge and students' misconceptions (Guncay & Gulbas, 2015).

From the description that has been revealed, it is found that the students sometimes have a different understanding with the experts, the result of this condition is the emergence of misconceptions. Misconceptions can be caused by an understanding that has formed before the formal teaching which is difficult to remove by the teacher. Teachers as a good educator should be able to reduce the potential emergence of misconceptions in their students. The first thing that can be done by the teachers is to know and understand the misconceptions appear in students. Therefore, researchers conducted a study to diagnose the students' misconceptions especially on hydrostatic pressure material, to help the teachers to have a better understanding of the potential misconceptions in the students.

#### **METHODS**

This research is a descriptive study using a quantitative approach as the representative of the research results. The sample in this study is SMAN 3 Malang class X MIA B who has studying the hydrostatic pressure material in the academic year 2015/2016. The respondents are 23 students consisting of 8 male students and 15 female students. The misconceptions in the diagnosis instruments are listed in Table 1.

The students of class X MIA B Malang are analyzed their misconceptions by providing four questions in the form of three-tier diagnostic test. The students are working on a three-tier diagnostic test for 20 minutes. The diagnosis data are presented in a form of a percentage of the total misconception and the total number of the students (23 students). In answering the questions on the multiple choice of the three-tier diagnostic test, students were asked to answer at level 1 anwer the questions, at level 2 the reasons of the choosen answers, as well as at the level 3 the students are required to provide the level of confiction in the accuracy of the answers given; by selecting the choice sure and unsure. Grouping students' conceptions based on three-tier diagnostic tests as in Table 2.

#### **RESULTS AND DISCUSSIONS**

#### The Students' Overall Concept about Hydrostatic Pressure Concept

The overall analysis results from the threetier instrument is classified as students who master the concepts is 22.8%, 29.1% did not know the concept, while the rest indicated misconceptions Many studies have shown that students tend to have developed their own understanding before the formal teaching is done 35, 9% and 2.2% or less confident guessing. For more fully data of the students' distibution conception on hydrostatic pressure can be seen in Table 3.

# C. P. Wijaya, Supriyono Koes H., Muhardjito / JPII 5 (1) (2016) 14-21

 Table 1. The misconception in diagnosis instruments

Indicators	Students' Misconception	No
Explaining t the depth of	he hydrostatic pressure on the same horizontal line is heavily influenced by the objects.	Items
	- Students believe that the hydrostatic pressure is directly proportional to the distance of a point on the surface of the water.	1
	- Students believe that the hydrostatic pressure has a greater value in a narrow place.	1
	- Students believe that the hydrostatic pressure is directly proportional to the height.	1
	- Students believe that hydrostatic pressure is greater at the outsideof the cave because it has a larger fluid volume so that the pressure is higher.	2
	- Students believe that the fluid is more concentrated when it is placed in a container, which is denser / narrower then the hidrostatic pressure becomes greater.	2
1	- Students believe that the depth in hydrostatic pressure is measured from the bottom of the fluid.	2
	- Students believe that the hydrostatic pressure is greater at the outside of the cave because the water outside the cave is more freely so that the pressure becomes smaller.	2
	- Students believe that the hydrostatic pressure is greater when the hole is wider.	3
	- Students believe that the hydrostatic pressure is greater when it is near an open hole.	3
	- Students believe that the hydrostatic pressure is greater when it is near a closed hole.	3
	- Siswa meyakini bahwa tekanan hidrostatis lebih besar pada rongga yang lebih sempit. Students believe that the hydrostatic pressure is greater in the narrower hole.	3
Explaining t	he hydrostatic preassure is proportional to the density of the fluid.	
	- Students believe that the hydrostatic pressure is inversely proportional to the density of the fluid.	4
2	- Students believe that the hydrostatic pressure is proportional to the mass of the object.	4
	- Students believe that the hydrostatic pressure is inversely proportional to the mass of the object.	4

Table 2. The Grouping Criteria of Students' Conception Based on Three-tier Diagnosis Test

Student	ts' Respo	nse					
An- swer	Code	Reason	Code	Convic- tion	Kode	Category	Code
True	В	True	В	Sure	Y	Mastering the concept	MK
True	В	False	S	Sure	Y	Misconception	Μ
False	S	True	В	Sure	Y	Misconception	Μ
False	S	False	S	Sure	Y	Misconception	Μ
True	В	True	В	Not sure	ΤY	Guessing, lack of confidence	ΤK
True	В	False	S	Not sure	ΤY	Not know the concept	TT
False	S	True	В	Not sure	ΤY	Not know the concept	TT
False	S	False	S	Not sure	ΤY	Not know the concept	TT

diadaptasi dari Arslan et al. (2012)

#### A Diagnosis in the indicator Explains that Hydrostatic Pressure is Influenced by Depth and All Points in the Horizontal Container in the Calm Fluid has the Same Hydrostatic Pressure

The question items to diagnose the students' misconceptions in the indicators are influenced by depth and all points located in the horizontal container in a calm liquid has the same hydrostatic pressure is presented in Figure 1, 2, and 3.

On the hydrostatic quention item in holes in the ground are presented in Figure 1 and the distribution of students' answers are presented in Table 3. The right answer on these items is the choice of answers D and the exact reason the choice of answers C. Based on these data; it appears that 30.4% of students master the concepts included in the category of hydrostatic pressure in a straight line on a similar fluid has the same mass. Mostly in the categories do not know the concept of which are 43.5% and 26.1% indicated misconceptions.

The students who are indicated have misconceptions in the question items in figure 1 are: 1) the student believes the hydrostatic pressure has a greater value in a narrow place by 13.1%, 2) the students experienced an error in determining the depth of 13%. The diagnosis is in line with the findings of the study from Besson (2004) which states that the hydrostatic pressure in a narrow place / container then the hydrostatic pressure will be greater, while the results of Goszewski et al. (2012) reported that students tend to have misconceptions in determining the depth in case of hydrostatic pressure.

On the question items of hydrostatic pressure for a fish which is inside and outside the cave are presented in Figure 2 and the distribution of the responses are presented in Table 3. In the question on the second image the right anwer choice is A and the right reason of answer choice is B. Based on these data seem that only 21.7% of students included in the category of knowing the concept of hydrostatic pressure in a straight

line on a similar fluid has the same mass. Most of the categories do not know the concept of 39.1%, 34.8% which are indicated to have misconceptions, and 4.3% to guess or lack of confiction.

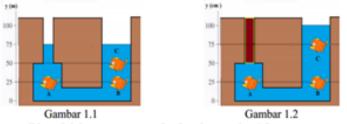
The students who indicated to have misconceptions on question items in the Figure 2, namely: 1) the students believe that hydrostatic pressure is greater at the outside of the cave because it has a larger volume so the pressure is higher (17.4%), 2) the students believe that the hydrostatic pressure at the outside of the cave is larger because the water is more freely so that the pressure becomes smaller (8.7%), 3) the students believe that the fluid is more concentrated when in a place, which is denser / narrower then the hydrostatic pressure becomes larger (4.3%), 4) the students believe that the depth of hydrostatic pressure is measured from the bottom of the fluid (4.3%). The diagnosis is consequence with the findings of recent research: 1) the hydrostatic pressure is proportional to the volume of fluid that is around the fish, 2) Beson (2004) at the outdoor, the air is free, so the hydrostatic pressure becomes smaller and at smaller place the water is more compressed.

On the question items of hydrostatic pressure, the points of the container which have open and close is presented in Figure 3 and the distribution of the responses are presented in Table 3. In Figure 3, the question items on the correct answer is D and the right reason of choice is A. Based on these data, it appears that only 21.7% of students are included in the category of knowing the concept of hydrostatic pressure in a straight line on a similar fluid has the same mass. At the categories who do not know the concept are 26.1%, 47.8% indicated as misconceptions, and 4.3% as guessing / do not convince with their answers. The students who are indicated having misconceptions on the question items in Figure 3, namely: 1) students believe that hydrostatic pressure is greater as it is closer to the point of closed hole (43.5%), 2) the students believe that the hydrostatic pressure in the narrower place

Table 3. The students' concept distribution on the hydrostatic pressure concept

Students' Response	Question						Number				
	Code		1		2		3		4		
Answer Reason Conviction	-	Ν	%	Ν	%	Ν	%	Ν	%	Ν	%
Mastering the concept	PI	7	30,4	5	21,7	5	21,7	4	17,5	21	22,8
Do not know the concept	TP	10	43,5	9	39,1	6	26,1	11	47,8	36	29,1
Misconception	Μ	6	26,1	8	34,8	11	47,8	8	34,7	33	35,9
Lucky guesses/not so convice	KP	0	0	1	4,3	1	4,3	0	0	2	2,2
		23	100	23	100	23	100	23	100	92	100

Ikan A, ikan B, dan ikan C masing-masing bermassa 2 kg berada di kedalaman seperti pada gambar 1.1, kemudian sebuah balok besar ditempatkan pada celah di atas ikan A sehingga permukaan air di atas ikan A mengalami penurunan dan permukaan air di atas ikan B dan ikan C mengalami kenaikan permukaan air, lalu air menjadi tenang kembali, posisi ikan A dan ikan B tetap sejajar dan tidak berpindah dari posisi awal kecuali hanya ikan C yang berpindah seperti pada gambar 1.2, jika diketahui pair = 1000 kg/l dan g = 10 m/s<sup>2</sup>.



Dari pernyataan di bawah ini mana yang tepat berdasarkan gambar 1.2...

- a. Ikan A merasakan tekanan dari air lebih besar daripada ikan B dan C.
- b. Ikan B merasakan tekanan dari air lebih besar daripada ikan A dan C.
- c. Ikan C merasakan tekanan dari air lebih besar daripada ikan A dan B.
- d. Ikan A dan B merasakan tekanan dari air yang sama besar.
- e. Ikan A dan C merasakan tekanan dari air yang sama besar.
- f. Ikan A, B, dan C merasakan tekanan dari air yang sama.

Alasan:

- a. Ikan A berada di tempat yang lebih sempit sehingga tekanannya lebih besar.
- b. Ikan B berada pada posisi 75 cm dari permukaan air.
- c. Ikan A dan ikan B berada pada garis horisontal yang sejajar.
- d. Ikan A memiliki jarak 25 cm dari penutup dan ikan C memiliki jarak 25 cm dari permukaan air.
- e. Ikan A terletak paling jauh dari permukaan air.

f. Ikan A, B, C berada pada fluida yang sama.

Apakah kamu yakin?

- a. Ya.
- b. Tidak.

Figure 1. The hydrostatic pressure in the holes of the ground question items

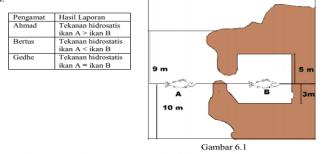
makes it larger (4.3%). The diagnosis is in line with the findings of several recent research: 1) Besson (2004) hydrostatic pressure will be larger at a closed hole, 2) Kariotoglou & Psillos (1993) hydrostatic pressure at the narrow container has a narrow greater pressure.

### The Diagnosis on the Indicators Explain that Hydrostatic Pressure has the Similar Density as Fluid

The Question items to diagnose the student has misconceptions on the indicators of hydrostatic pressure is proportional to the density of the fluid is presented in Figure 4. The distribution of the students' answers is presented in Table 3. The answer in Figure 4 which is the right answer is A and the right reason at the answer is C. Based on the data shows that only 17.4% of students are included in the category of knowing the concept of hydrostatic pressure is influenced by the density of the fluid. Most of the students are in the category of do not know the concept 47.8% and 34.7% indicated misconceptions. The misconception that indicated in students within the question items in Figure 4 are 1) the students believe that the hydrostatic pressure is proportional to the density of the submerged object which amounted to 30.4%, 2) students believe that hydrostatic pressure is inversely proportional to the density of the submerged object of 4.3.

#### CONCLUSION

Based on the results and explanation as described before, it can be concluded that based on the diagnosis by using Three-tier methods, there are students who indicated are having misconceptions associated to hrydrostatic pressure, covering the indicators which is explain the hydrostatic pressure that influenced by the depth and all points located in the horizontal place in a calm liquid has the same hydrostatic pressure and indicators explain the hydrostatic pressure is proportional to the density of the fluid was found that as many as 22.8% of students in masDilakukan pengamatan terhadap ikan A bermassa 2 kg yang berada di luar gua dan ikan B bermassa 2 kg yang berada di dalam gua, seperti pada gambar 6.1. Diketahui  $\rho_{air} = 1000 \text{ kg/l dan g} = 10 \text{ m/s}^2$ . Pengamat tersebut ialah Ahmad, Bertus, dan Gedhe. Hasil pengamatan masing-masing pengamat yaitu:



Dari ketiga laporan tersebut yang mempunyai hasil laporan yang benar adalah...

- a. Gedhe, Ikan A dan B merasakan tekanan yang sama besar dari air danau.
- b. Ahmad. Tekanan ikan A > ikan B.
  c. Bertus,. Tekanan ikan A < ikan B.</li>
- Alasan:
- Ikan A berada di luar gua mempunyai meter kubik air yang lebih banyak sehingga tekanannya lebih tinggi.
- b. Ikan A dan ikan B terletak pada satu garis horizontal yang sejajar.
- Ikan B berada di dalam mempunyai air yang lebih terkonsentrasi ketika di tempat yang lebih rapat.
- Ikan A merasakan tekanan dari air danau yang berada pada kedalaman 10 m dari dasar permukaan air.
- Ikan A berada di luar gua karena air yang berada di luar gua lebih bebas sehingga tekanannya lebih kecil.



Figure 2. The question items of hydrostatic pressure of the fish inside and outside of the cave

Sebuah wadah yang terbuka pada salah satu sisinya ditunjukan pada gambar 4.1. Jika wadah tersebut berisi cairan yang bermassa jenis 100 kg/m<sup>3</sup>, maka pernyataan di bawah ini yang benar adalah...

- Tekanan hidrostatis di titik D dan A sama serta lebih besar dari titik C dan B.
- b. Tekanan hidrostatis di titik A paling besar.
- c. Tekanan hidrostatis di titil D paling besar.
- Tekanan hidrostatis di titik C dan D sama serta lebih besar dari titik A dan D.

Alasan:

- a. Dalam posisi horisontal yang sejajar.
- b. Paling dekat dengan rongga yang tertutup.
- c. Paling dekat dengan rongga yang terbuka.
- d. Terletak pada rongga yang lebih sempit.
- e. Terletak pada rongga yang lebih luas.

Apakah kamu yakin?

- a. Yakin.
- b. Tidak.

Figure 3. The question items of hydrostatic pressure in a container which has open and close holes

tering the concept category, 39.1% did not know the concept, while 35.9% indicated experiencing misconceptions, and the balance of 2.2% in the category of guessing or less convince than a total of 23 students who took the tests.

The type misconceptions that often happend in this study are: 1) students believe that hydrostatic pressure is greater at a point closer to the closed hole (43.5%), 2) students believe that hydrostatic pressure is proportional to the density of the submerged object (30.4%), 3) the students believe that the hydrostatic pressure is greater outside of the cave because it has a larger volume of fluid so that the pressure is higher (17.4%), 4) the students have misconceptions in determining the depth in case of hydrostatic pressure (13%), 5) the students believe that the hydrostatic pressure is greater in a narrow place (13%).

Gambar 4.1

To prevent the misconceptions in students, researchers suggest to the reader as well as further research for the diagnosis of misconceptions before proceeds a learning process to the students, misconceptions that have grown need a further evaluation on the sources causes of misconcep-

P. A.

y (cm)

100

75

50

25

0

Hasil praktikum kimia yang dilakukan Andi adalah sebagai berikut:

Jenis Zat	Massa jenis (g/cm <sup>3</sup> )
Alumunium	2,70
Besi	7,86
Air laut	1,25
Air danau	1,00

Berdasarkan tabel di atas, maka pernyataan di bawah ini yang tepat ialah...

- a. Besi memiliki tekanan hidrostatis lebih besar daripada almunium ketika dicelupkan ke dalam air laut.
- b. Almunium yang dicelupkan dalam air danau memiliki tekanan hidrostatis lebih besar daripada almunium yang dicelupkan pada air laut.
- Almunium memiliki tekanan hidrostatis lebeih besar daripada besi ketika dicelupkan dalam air c. laut.
- Besi yang dicelupkan dalam air laut memiliki tekanan hidrostatis lebih besar daripada besi yang d. dicelupkan dalam air danau.

Alasan:

- Tekanan hidrostatis berbanding lurus dengan massa jenis benda yang tercelup. a.
- Tekanan hidrostatis berbanding terbalik dengan massa jenis benda yang tercelup. b.
- Tekanan hidrostatis berbanding lurus dengan massa jenis fluida. c. Tekanan hidrostatis berbanding terbalik dengan massa jenis fluida.

Apakah kamu yakin dengan jawaban yang kamu berikan?

a Yakin Tidak.

b.

Figure 4. The question items of hydrostatic pressure on the laboratorium data results

tions caused by students and other sources such as teachers, learning methods, textbooks, and reference books, doing a diagnosis research of misconceptions in other materials as well as efforts to overcome the misconception that indicated on the students, doing similar research by using more samples, so the results are more accurate.

#### REFERENCES

- Arslan, H. O., Cigdemoglu, c., & Moseley, c. (2012). A three-tier diagnostic test to assess pre-service teachers' misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain. International Journal of Science Education, 34(11), 1667-1686.
- Atwood, R. K. & Atwood, V. A. (1997). Effects of instruction on pre-service elementary teachers conceptions of the causes of night and day and the seasons. Journal of Science Teacher Education, 8(1), 1-13.
- Besson, U. (2004). Students' conceptions of fluids. International Journal of Science Education, 26(14), 1683-1714.
- Brunsell, E. & Marcks, J. (2005). Identifying a baseline for teachers astronomy content knowledge. Astronomy Education Review, 2(3), 38-46.
- Caleon, Imelda & Subramaniam. (2010). Development and Application of a Three-Tier Diagnostic Test to Assess Secondary Students' Understanding of waves. International Journal of Science Education, 32(7), 939-961.
- Chambers, S. K., & Andre, T. (1997). Gender, Prior Knowledge, Interest, and Experience in Electricity and Conceptual Change Text Manipulations in Learning about Direct Current. Journal of Research in Science Teaching, 34(1), 107-123.
- Driver, R. A. Squires, Rushworth, P & Robinson, V. W. (1994). Making Sense of Secondary Science: Re-

search into Children's Ideas. New York: Routlege.

- Eryilmaz, A. (2010). Development and Application of Three-tier Heat and Temperature Test: Sample of Bachelor and Graduate Student. Eurasian Journal of Educational Research 40(1): 53-76.
- Eryilmaz, A., & E. Sürmeli. (2002). "Üç-Aşamalı Sorularla Öğrencilerin Isı ve ıcaklık Konularındaki Kavram Yanılgılarının Ölçülmesi [Identifying Students' Misconception on Heat and Temperature through Three-Tier Questions]." Paper presented at the 5th National Conference on Science and Mathematics Education. Accessed February 7, 2011.
- Franklin, B. J. (1992). The Development, Validation and Application of a Two-tier Diagnostic Instrument to Detect Misconceptions in the Areas of Force, Heat, Light and Electricity. Unpublished doctoral dissertation, Louisiana State University and Agricultural and Mechanical College
- Goszewski, Matthew., Moyer, Adam., Bazan, Zachary, & Wagner, DJ. (2012). Exploring student difficulties with pressure in a fluid. PERC Proceedings, Published by the American Association of Physics Teachers under a Creative Commons Attrihution
- Guncay, D. & Gulbas, E. (2015). Development of three-tier heat, temperature, and internal energy diagnostic test. Research in Science & Technological Education, 5(1), 223-233.
- Halim, L., Yong, T. K., & Meerah, T. S. M. (2014). Overcoming students' misconceptions on forces in equilibrium: an action research study. Creative Education, 5(1), 1032-1042.
- Hammer, D. (1996). More than misconceptions: multiple perspectives on student knowledge and reasoning, and an appropriate role for education research. American Journal of Physics, 64(1), 1316-1325.
- Ivowi, U.M.O. & Uludotun, J.S.O. (1987). An investigation of resourses of misconception in phys-

ics. Dalam Novak, J.D. (Ed). Proceeding of the second international seminar misconception and educational and strategies in science and mathematics, (3). Ithaca, New York: Cornell University

- Kariotoglou, P. & Psillos, D. (1993). Pupils' Pressure Models And Their Implications For Instruction. *Research In Science And Technological Education*, 11(1), 95–108.
- Kirbulut, Zubeyde Demet. (2014). Using Three-Tier Diagnostic Test to Assess Students' Misconceptions of States of Matter. Eurasia Journal of Mathematics, Science & Technology Education, 10(5), 509-521.
- Küçüközer, H. (2007). Prospective science teachers" conceptions about astronomical subjects. *Science Education International*, 18(2), 113-130.
- Kutluay, Yasin. (2005). Diagnosis of Eleventh Grade Students' Misconceptions about Geometric Optic by a Three-Tier Test. Thesis. Middle East Technical University
- Lawson, A. E. (1995). Science Teaching and the Development of Thinking. Belmont, CA: Watsworth Publishing Company
- Peşman, H., & A. Eryilmaz. (2010). Development of a Three-tier Test to Assess Misconceptions about Simple Electric Circuits. *The Journal of Educational Research*, 103(1), 208–222.
- Pratiwi, A & Wasis. (2013). Pembelajaran dengan praktikum sederhana untuk mereduksi miskonsepsi siswa pada materi fluida statis di kelas XI SMA Negeri 2 Tuban. *Jurnal Inovasi Pendidikan Fisika, 2*(3), 117-120.
- Sencar, S., & Eryilmaz, A. (2004). Factors mediating the effect of gender on ninth-grade turkish students' misconceptions concerning electric circuits. *Journal of Research in Science Teaching*, 4(1), 603-616.
- Soyinbo, K. (1993). Some Sources Of Students' Misconceptions In Biology. A Review In The Proceedings Of The Third International Seminar On Misconceptions And

Educational Strategies In Science And Mathematics, Misconceptions Trust: Ithaca, NY, USA.

- Stover, S. & Saunders, G. (2000). Astronomical misconceptions and the effectiveness of science museums in promoting conceptual change. *Journal of Elementary Science Education*, 12(1), 41-52.
- Tan, K. C. D., Goh N. K., Chia L. S., & Treagust D. F. (2002). Development and application of a twotier multiple choice diagnostic instrument to assess high school students' understanding of inorganic chemistry qualitative analysis. *Journal* of Research in Science Teaching, 39(4): 283–301.
- Trumper, R. (2003). The need for change in elementary school teacher training-a cross-college age study of future teachers conceptions of basic astronomy concepts. *Teaching and Teacher Education*, *19*(1), 309-323. doi:10.1016/S0742-051X(03)00017-9
- Tsai, C. C. (1999). Overcoming junior high school students' misconceptions about microscopic views of phase change: a study of an analogy activity. *Journal of Science Education and Technology*, 8(1), 83-91.
- Türker, F. (2005). Developing a Three-tier Test to Assess High School Students' Misconceptions Concerning Force and Motion. Tesis. Middle East Technical University.
- Wong, T. K., & Sulaiman, S. (2008). The Level of Alternative Framework among Form Five Science Stream Students on the Topic of Buoyancy. *National Conference of Science* and Mathematics Education, Johor, Malaysia.
- Yalcin, M, Altun, S, Turgut, U, & Aggul F. (2008). First Year Turkish Science Undergraduates' Understanding and Misconceptions of Light. *Sci & Educ*, 18(1), 1083-1093.





Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

## THE DEVELOPMENT OF SCIENTIFIC-APPROACH-BASED LEARNING INSTRUMENTSINTEGRATED WITH RED ONION FARMING POTENCY IN BREBES INDONESIA

## D. Setiawan<sup>\*1</sup>, I. Wilujeng<sup>2</sup>

<sup>1</sup>SMPN 1 Bulakamba Kabupaten Brebes; <sup>2</sup>Universitas Negeri Yogyakarta, Indonesia

#### DOI: 10.15294/jpii.v5i1.5785

Accepted: 4 January 2016. Approved: 25 March 2016. Published: April 2016

#### ABSTRACT

This study aimed to describe the eligibility category of science learning instrument based on scientific approach integrated with onion farming potency. Also, this study aimed to analyze the effectiveness of the application of the science learning instrument in terms ofscience process skills development and the cognitive learning outcomes in the student of class VII SMPN 1 Bulakamba. This study used thedevelopment research methods by adapting the 4D model that includes define, design, develop, and disseminate. The learning instruments developed in this research were the learning implementation plan (RPP) and the student worksheet (LKS). The data collection was done by using non-test technique using interview guides, product validation sheet, students' response sheet to the readability of LKS and the instructional observation sheets; as well as using theworksheet of process skills and cognitive learning potency was categorized as excellent. The application of scientific-approach-based learning instruments was effective to improve the process skills and the students' cognitive learning outcomes in class VII SMPN 1 Bulakamba.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: onion farming in Brebes, science learning instruments, scientific approach.

## INTRODUCTION

Red onion (*Allium cepa* var. *Ascalonicom*) is one of Indonesia's leading horticultural commodities (Wahyudin et al., 2015). The demand of red onion for consumption and its seeds has continued to increase by year (Sumarni et al., 2012). Red onion is usually used as a spice in cooking and is also often used as as a traditional medicine for wounds, stomach ulcers, colds, lowering thesugar level and loweringthe cholesterol level in blood (Princess &Watemin, 2014).

Brebes district in Central Java is the main red onion supplier in Indonesia. In 2014, the area of red onion farms in Brebes district reached 30,954 ha with a total production 375,974 tons. This pro-

\*Alamat korespondensi:

Email: dani.setiawan@ymail.com

duction reached 72.39% of the total red onion production in Central Java. The 2014 red onion production obtained from Brebes district has increased by 71,217 tons compared to the total production in 2013 (BPS Central Java, 2015).

The farmers have succeeded to develop thered onion as the potential and main commodityas a regional identity of Brebes. They have a particular way on cultivating the red onion that can be categorized as a local genius. Their knowledge on the red onion cultivation has been maintained from generation to generation without any scientific explanation on how to grow the onions. They are taught directly by the ancestors in obtaining the onion farmin method (Khusniati, 2014).

The red onion farming has a main contribution for society towards economic function, i.e. as a source of earnings. People can work either

as farmers, farm laborers, or onion seller. As an object of learning, the onion farms are promising to provide the alternative learning resources for science topics, such as biodiversity, and ecosystems. Nana & Salamah (2014) studied the growth mechanism process of onion plants by coconut water addition as a source of biology learning in high school students Class XII. The utilization of the onion farming potential as a learning resource is a form of the implementation of the National Education System law number 20 year 2003 article 36. It is kind of a mandatory for the school to prepare the curriculum which involves the local wisdom, biodiversity and the environment potencies. The mandate provides a great opportunity for teachers in Brebes to raise the agricultural potency of onion into learning materials.

The opportunity to raise the issue of red onion agricultural potency into science teaching is still rarely done by the science teacher in Brebes. The results of the interview with the science teacher at SMPN 1 Bulakamba Brebes revealed that some teachers have been using the local potencies as the learning material. However, it is still limited to a specific material and has not been raised explicitly in the lesson plandocumentsor rencana pelaksanaan pembelajaran (RPP). The local potency has also been utilized in the students' scientific project group or karya ilmiah remaja (KIR) and in the craft study subject. There were some technical problems and obstacles faced by teachers when utilizing local potencies in learning activity and it were limited to a particular study material. The technical problems were related to the lack of guidance on how to integrate theobject of local potencies into the RPP. The local potencies are limited to a particular topic of study; therefore, it could not be applied to all science learning materials.

The integration of the onion agricultural potency on science learning should have a goalto be a student learning whole achievement in accordance with the nature of science, i.e. science as a process, knowledgeproduct, the attitude development, and science application (Erina & Kuswanto, 2015; Pratiwi, et al., 2014; Yanti, et al., 2013). The science processes are related to the problem solving procedures through scientific approaches. For example, curiosity and openended skills are included in the scientificattitude, whereas the facts, principles, theories, concepts, and law are included as the science products. Moreover, the science application is related to the application of scientific methods and concepts of science in everyday life.

Science learning as a process provides

the opportunity for students to interact with the science objects and actively engage in the process skills (Abungu et al., 2014). The science process skills are the reflection of thinking skills scientific methods used by the sciencetist for building the knowledge (Sheeba, 2013; Özgelen, 2012).Science process skills are the basic of IPA problem solving in the scientific method (Wilujeng, et al., 2010). Moreover, the development of processing skilss at school could help the students to learn how to solve the problems (Abungu et al., 2014), to develop learning through experience (Rauf et al., 2013), to improve learning outcomes (Ergul et al., 2011; Wardani et al. 2009), and to improve creative thinking skills (Rahayu et al., 2011). The development of process skills also helps students to think logically, to think critically, to ask reasonable questions, and to seek answers that can solve problems in everyday life (Ergul et al., 2011).

The results of a preliminary observation on the learning process in high school students showed a fact that some process skills such as observing, measuring, predicting and communicating were not observed in the learning process. These facts indicated that science learning process skills was needed to be improved. Based on the results of interviews with the science teacher at SMPN 1 Bulakamba the aspect of knowledge (cognitive) also needed to be improved. Some teachers realized that there were who have not reached the minimum completeness of the specified criteria. The results of the midterm test (ulangan tengah semester) 1 in the academic year 2015/2016 in SMPN 1 Bulakamba showed that the average scores of seventh grade students in the science subjects only reached 65.8. Students who achieve the minimum criteria only reached 13.10% or 11 students out of 82 students (VII. C 42 students; VII.D 42 students).

One of efforts to develop the process skills and to increase the students' cognitive learning outcomes can be made by applying the learning activities that emphasize the student active involvement (Akinbobola & Afolabi, 2010) or the practice of scientific investigations (Ango, 2002). Moreover, an effort that can be done is to adopt a scientific approach. Scientific approach is a learning approach that emphasizes the process skills (Sujarwanta, 2012). Learning activities with a scientific approach includes activities to observe, to ask, to gather the information, to associate, and to communicate (Wijayanti, 2014). Results of Yeni et al. (2015) and Machin (2014) studies showed that the application of a scientific approach for learning showing a positive effect on the cognitive learning, affective and psychomotor.Marjan et al. (2014) reported that a scientific approach to improve learning outcomes and basic science process skills of students. Wijayanti (2014) reported that the implementation of project-based authentic assessment with effective scientific approach could improve the scientific thinking skills.

Machin (2014) mentioned that the scientific approach was the application of contextual learning. As a contextual learning, scientific approach can be integrated with contextual learning resources around the students, such as agricultural potential. Knobloch et al. (2007) stated that agriculture provided a context for discussing the relationship between nature and human needs. Cepni et al. (2011) research results showed that the use of agricultural assisted modules of student worksheets or lembar kerja siswa (LKS) was effective in developing a conceptual understanding of elementary school students on the concept of agriculture. Mabie & Baker (1996) reported that the participation of students in agricultureoriented activities have positive impact on the development of science process skills of students which include observing skills, communication, compare, connect, order, and concludes. The use of the agricultural context by Balschweid (2002) on the biology learning could help students in understanding the relationship between science with agriculture.

The scientific approach and the utilization of agricultural contextual learning resources could be applied to overcome the problems of students' process skills and cognitive learning outcomes in class VII SMPN 1 Bulakamba using the adoption of an integrated scientific approach with the agricultural potency of onion. The use of integrated learning instruments could provide an answer for some problems in scientific learning, noting some of the constraints faced by teachers in implementing these efforts. This study aimed to describe the eligibility criteria and to analyze the effectiveness of learning instruments based on scientific approach application which integrated with the onion agricultural potency in terms of the process skills improvement process and the cognitive learning outcomes in students of class VII SMPN 1 Bulakamba.

#### **METHODS**

This research used the method of research and development which adapted to the 4D model of Thiagarajan et al. (1974). The research stages included the define, design, develop, and disseminate. In this study, the products developed was in the form of science learning instruments based on scientific approach which integrated with the agricultural potential of red onion in Brebes, i.e. lesson plan documents or *rencana pelaksanaan pembelajaran* (RPP) and student worksheet or *lembar kerja siswa* (LKS). Products were developed to improve the science process skills and cognitive learning outcomes in the seventh grade of junior high school students on the topic of science object and observations.

Product trials were conducted in October to December 2015 at SMPN 1 Bulakamba Brebes. Product trials were conducted in two phases, namely the limited field trial (trial I) and the main field trial (trial II). The first trial was carried out in the non-class samples to analyze and to gain direct input in the form of responses, reactions, comments of teachers and students. The first trial was conducted on the subject amounted to 12 students of class VII.

The first trial test design used the method of pre-experiment with a one-group pretestposttest design (Sugiyono, 2012). The second trial test used thequasi-experiment with non-equivalent control group design (Sugiyono, 2012).

The second trial test used two classes, i.e. the class that applied the learning instruments based on the scientific approach which integrated with the red onion agriculture potency (as an experimental class)and the control class without integrated learning tools. The experimental class and control class were selected with preceded by pre-test and post-test. There was a span of time between the pre-test and post-test, thus the results were not affected by the pre-test and post-test.

The subject of this study was the students of class VII SMP N 1 Bulakamba Brebes in first semester of academic year 2015/2016. The subjects to limited trial (trial I) were 12 students of class VII were selected randomly. The main subject of field trials (trial II) composed of class VII A and VII B selected from nine classes of grade VII in SMPN 1 Bulakamba. The determination of the experimental class and the control class was done randomly with the results of class VII A as an experimental class and class VII B as the control class. The data collection was done by (1) non-test techniques using interview guides, product validation sheet, students' worksheet response to the readability and instructional observation sheets; and (2) the testing techniques used a booklet about the process skills and cognitive learning outcomes sheet.

The feasibility of learning instruments and student response to the legibility of worksheets were analyzed qualitatively based on the classification of four categories, namely: (1) very good: the interval score  $3.25 < X \le 4.00$ ; (2) good: 2.50 < X  $\le 3.25$ ; (3) Poor:  $1.75 < X \le 2.50$ ; and (4) very poor:  $1.00 \le X \le 1.75$ . The table of four categories classification was arranged according to the guidelines of Widoyoko (2012).

The implementation of science learning using scientific-approach-based learning integrated with the agricultural potential of onion were analyzed by calculating the percentage of enforceability of learning activities aspects on the observation sheet. The result of the calculation of the implementation adherence percentage with the classification of four categories, namely: (1) very good: 75% percentage interval  $<X \le 100\%$ ; (2) either: 50%  $<X \le 75\%$ ; (3) poor: 5%  $<X \le 50\%$ ; and (4) very poor: 0%  $\le X \le 25$ .

The improved learning outcomes were analyzed based on the normalized gain average score ( $\langle g \rangle$ ) using the following equation.

$$< g >= \frac{<\% post > - <\% pre >}{100 - <\% pre >}$$

Description:

<g> = average score of normalized gain <%post> = average percentage of post-test score gained by students

<%*pre>* = average percentage of pretest score gained by students (Hake, 2007).

Value of obtained  $\langle g \rangle$  was consulted with three categories, namely (1) high:  $\langle g \rangle \ge 0.7$ ; (2) medium:  $0.3 \le \langle g \rangle < 0.7$ ; and (3) low:  $\langle g \rangle < 0.3$  (Hake, 1998).

The effectiveness of the application of the learning instruments in the first trial was analyzed based on the normalized gain average score gain and Wilcoxon tests. The effectiveness of second trial was analyzed based on the normalized gain average score and multivariate Hotelling's Trace test to normalized gain score of each student. The normalized gain score for each student. (g) obtained by the following equation.

$$g = \frac{postscore\% - prescore\%}{100 - \% pretest}$$

Description:

g = normalized gain score

% *postscore* = percentage of students' post-test scores

% *prescore* = percentage of students' pre-test scores

(Coletta et al., 2007)

#### **RESULTS AND DISCUSSION**

The result of this study was an end product; a scientific-approach-based learning instrument integrated with red onion agriculture potency in Brebes, Central Java Indonesia. The implemented activities of scientific approach were observation, formulate questions, data collection, data association, and communicating the results. The developed learning instruments were the lesson plan documents (RPP) and student worksheet (LKS) on the subject of science object and its observation in class VII first semester.

RPP was designed with reference to the format of the Regulation of the Minister of Education and Culture (Permendikbud) No. 103 year 2014 on Education in Primary and Secondary Education. RPP components include 1) the identity of the school/ madrasah, subjects, and grade/semester; 2) time allocation; 3) KI, KD, and indicators of achievement of competencies; 4) learning materials; 5) learning activities; 6) assessment; and 7) media/instruments, materials, and learning resources.

Learning activities in RPP was designed for five meetings with the allocation of 12 hours of lessons (JP). The learning activities were designed with the strategy of indoor and outdoor learning. The indoor learning strategy was designed at the meeting of the 1st, 3rd, and 4th. While outdoor learning strategy was designed at the 2nd meeting. The first meeting was designed to study the science objects sub topics and process skills a 2-hour lesson or jam pelajaran (JP). The second meeting was completed to study the unit and measurements sub topics with time allocation of 3 JP. The third meeting was conducted to study the sub-topic of the principal scales with 2 JP time allocations. The 4th meeting was used to study the derivative scales sub topics 3 JP time allocations. Lastly, the 5th meeting was designed for the implementation of the review tests and the with 2 JP time allocations.

LKS was developed to support the learning activities that have been designed on the RPP. LKS components include title, introduction, objectives, tools and materials, work step, observation data, a list of questions and conclusions. LKS is designed with five activities as follows. *LKS 01 Red onion observation* 

LKS 01 was designed to be used in the first meeting to guide the students to observe the onion as a science object and to introduce some of the science process skills such as observing, estimating, classifying, measuring, inferring, and communicating.

# LKS 02 Measuring the science object in red onion fields

LKS 02 was designed to be used in the second meeting to guide students in doing the measurement of science objects in the red onion fields.

#### LKS 03 Measure the principal scales of red onions

LKS 03 was designed to be used in the third meeting to guide the students to perform the measurements on the principal measurement of onion.

#### LKS 04 Measurement of the derivative scales in onion

LKS 04 was designed to be used in all four meetings to guide the students to perform the derivative scales measurement of quantities in onion.

#### LKS 05 Measuring the growth rate of red onion

LKS 05 was designed to guide students in determining the rate of growth of the onion. LKS 05 was part of the 4th meeting of the activities carried out outside regular instructional hours. Information in LKS 05 activities were presented at the 1st meeting.

The results of the feasibility assessment of RPP by eight validators are presented in Table 1. Table 1 notes that RPP developed included in the excellent category with an average score reached 3.86. The results of the assessment of the validator showed that the developed RPP was eligible for use in the learning process after being revised in accordance with the advice and input from the validator.

The results of the worksheets feasibility assessment are presented in Table 2. Table 2 note that the worksheets that were developed included in the excellent category with an average score reached 3.76. The results of the assessment indicated that the developed LKS developed was eligible for use in the learning process after being revised in accordance with the advice and input of the validator.

The worksheet eligibility is strengthened by the results of student questionnaire responses on the worksheet legibility in the aspects of the views presented in Table 3. According to Table 3 it can be seen that the presentation of the image and the performance was categorized as an excellent; such as the layout of images, tables, and statements; also the display name, description, instructions, pictures, tables, and questions were very well categorized; and the use of language was very good. In general, all aspects of the worksheets were excellent according to the students' opinion.

The feasibility of the developed learning instruments were also supported by the ease of teachers in implementing the learning instruments. Results of the trial I indicated that the category of the implementation of learning aspects were observed on-one meetings to include both categories (73.33%), whereas the second meeting was in good category (70%), the third meeting was good (73.33%), and lastly, the fourth meeting was excellent (76.67%). The percentage of the

Aspects	Average Score	Category
Formulation of RPP	3.88	Very good
Time allocation	3.88	Very good
Formulation of core competencies (KI), basic competencies(KD), and competency achievement indicators	3.75	Very good
Selection of learning materials	3.88	Very good
Formulation of learning activity	3.88	Very good
Formulation of assessment, remedial learning and enrichment	3.97	Very good
Selection of media/tools, materials and learning resources	3.81	Very good
Average	3.86	Very good

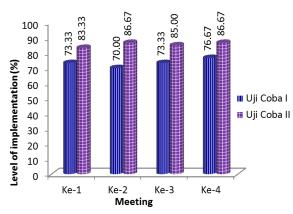
Table 2. Results of the worksheets feasibi	lity assessment
--	-----------------

Aspects	Average score	Category
Material presentations	3.80	Very good
Activity planning aspect	3.98	Very good
Performance	3.50	Very good
Average	3.76	Very good

Aspects	Average score	Category
Image presentation and performance	3.67	Very good
Images, tables, and questions layout	3.17	Good
Presentation of title, description, instructions, pictures, tables, and questions	3.58	Very good
Language usage	3.67	Very good
Average score	3.52	Very good

Table 3. Results of student response on theworksheet (LKS) Readability

implementation aspects were observed increased in major field trials (trial II), namely to 83.33% at the first meeting, 86.67% at the second meeting, 85.00% in third meeting, and 86.67% in the 4th meeting (Figure 1).



**Figure 1.** Learning implementation level in trial I and II

The effectiveness of the application of scientific-approach-based learning instruments integrated with the agricultural potential of red onion known through limited field trial and the main field trials. Based on limited testing, it showed that the application of the developed learning tools could increase the skills and the cognitive learning process. The results of the analysis of the average score of normalized gain (<g>) showed the improvement of science process skills and cognitive learning outcomes in a medium category (Table 4).

**Table 4.** Gain category on the field limited trial test

Response variable	<g></g>	Category
Science process skills	0.38	Medium
Cognitive learning out- comes	0.54	Medium

The improvement of skills in every aspect of the science process skills as measured on a field trial test can be seen from a comparison of the percentage of the acquisition of science process skills scores obtained by all students at the post-test and pre-test which presented in Figure 2.

Based on Figure 2 it can be seen that the post-test score was higher than the pre-test score. This result suggested that the skills of the students has increased after treatment. Test result data was paired with the value of pre-test and post-test with the Wilcoxon test to find out whether any changes on the process skills and the cognitive learning results after following the science learning by applying the learning instruments or not. Wilcoxon test that had been selected for sampling in limited trial did not meet the assumptions of normality and homogeneity.

Results of the Wilcoxon test for the skills acquired of Z value at -2.941 with Asymp. Sig 0.003; whereas the cognitive learning Z value was at -3.069 with Asymp value.Sig 0.002. All values Asymp. Sig. obtained were <0.05, which meant that there were the significant differences between the average value of pre-test and post-test of process skills, the cognitive learning, and environmental consideration attitude. Thus, based on limited trial, the application of the learning instruments was effective to improving the process skills and the cognitive learning.

The effectiveness of the learning instruments which developed based on scientific approach integrated with the onion agriculture potency on improving the process skills and cognitive learning was measured by comparing the average gain scores between the experimental class and control class. The results of the analysis of the normalized gain average score (<g>) on each class of test samples are presented in Table 5.

Based on Table 5, the improvement of science process skills in the experimental class and in the control class were categorized as medium. Based on the value of  $\langle g \rangle$  the science process skills in the treatment class was ( $\langle g \rangle = 0.54$ ) greater than the control class ( $\langle g \rangle = 43$ ). The improvement in the cognitive learning achie-

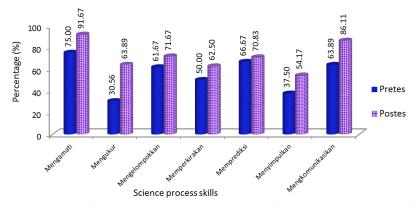


Figure 2. Percentage graph of gained scores in every aspect of science process skills of all students in the limited trial test

<b>Table 5.</b> Category of the improvement in	the main field tria	l test
--	---------------------	--------

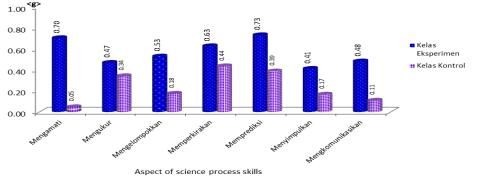
Dagagaga yariahlag	Experimental class		Control class	
Response variables	<g></g>	Category	<g></g>	Category
Science process skills	0.54	Medium	0.43	Medium
Cognitive learning outcomes	0.50	Medium	0.47	Medium

vement of students in the experimental class and control class were categorized as medium. Based on the value of  $\langle g \rangle$  the increase in cognitive learning outcomes in the experimental class ( $\langle g \rangle = 0.50$ ) was greater than in the control class ( $\langle g \rangle = 0.47$ ).

The comparison of process skills improvement based on the normalized gain average score in every aspect of skills was measured on each sample are presented in Figure 3. Based on Figure 3 it can be seen that the increase in every aspect of students' science process skills in the experimental class was higher than in the control class. The results of different test groups with Hotelling's Trace test obtained significance value of 0.036 (Sig. < 0.05), which means that H0 was rejected. Thus there was a difference in the average score of science process skills and cognitive learning outcomes among students in the experimental class and the control class. This means that the application of the learning instruments was more effective to improve the process skills and cognitive learning outcomes of students in class VII SMPN 1 Bulakamba compared with the implementation of a learning tool used by teachers.

The results of limited and main trial tests showed that that the application of the integrated learning instruments was effectively improve the skills and cognitive learning outcomes of students. The results were consistent with the results of research of Marjan et al. (2014) which showed that the application of scientific approach can improve the skills of process and biology student learning outcomes. The results of this study were also consistent with the results of research Yeni et al. (2015) and Machin (2014) which showed that the application of scientific approach gave the positive effect on improvement of cognitive learning outcomes. The application of scientific-approach-based learning could improve the skills of the operational process because the scientific approach was emphasized on process skills (Sujarwanta, 2012). The main activity of the scientific approach, such as observing, asking, gathering the information/data, associating the information, and communicating skills was the implementation of the process itself. Learning that emphasizes process skills can help students to improve student learning outcomes (Ergul et al., 2011; Wardani et al., 2009).

The effectiveness of the learning instruments in this study was in accordance to the results of Mabie & Baker (1996) study which suggested that the participation of students in agriculture-oriented activities had shown the positive impact on the development of science process skills of students. The results of this study were also consistent with the results of research Balschweid (2002) which showed that the use of agricultural contexts could help students to understand the relationship of science to agriculture. The integration of the agricultural potential of onion in learning instruments was in line with the basic theory that asserts the importance of experiential learning activities in the learning ex-



Aspect of science process skins

Figure 3. Comparison graph <g> of every aspect of science process skills between the experimental class and control class in the main trial test

perience (Healey & Jenkins, 2000; Knobloch et al., 2007). Basic theory of learning experiences shows that the relationship between context and content gave the students the chance to learn and transfer the overlapping concept that is complementary (Balschweid, 2002).

#### CONCLUSION

Based on the results and discussion of research and development of science learning instruments it can be concluded that: (1) the eligibility of integrated science learning instruments was in excellent category for its lesson plan and students' worksheets; and (2) the application of scientific-approach-based learning instruments was effective to improve the process skills and cognitive learning outcomes of students of class VII SMPN 1 Bulakamba.

The application of the integrated learning instruments was to improve science process skills and cognitive learning outcomes of students on the topic of science objects and observations in SMP Negeri 1 Bulakamba. Scientific approach recommended by Permendikbud no. 65 year 2013 on Standards for Primary and Secondary Education Process concurrently with the implementation of Curriculum 2013 in some schools/ areas. Accordingly, the science teacher in Brebes and other areas with onion agriculture potencies can utilize the learning instruments developed for the learning process on the topic of science object and observations. Further research can be conducted to determine the effectiveness of an integrated scientific-approach-based learning instrument in the other science subjects.

#### REFERENCES

Abungu, H. E., Okere, M. I., & Wachanga, S. W. (2014). The Effect of Science Process Skills Teaching Approach On Secondary School Students' Achievement In Chemistry in Nyando District, Kenya. *Journal of Education and Social Research*, 4(6), 359-372.

- Akinbobola, A. O., & Afolabi, F. (2010). Analysis of Science Process Skills in West African Senior Secondary School Certificate Physics Practical Examinations in Nigeria. *American-Eurasian Journal of Scientific Research*, 5(4), 234-240.
- Ango, M. L. (2002). Mastery of science process skills and their effective use in the teaching of science: an educology of science education in the Nigerian context. *International Journal of Educology*, 16(1), 11-30.
- Balschweid, M. A. (2002). Teaching Biology Using Agriculture As The Context: Perceptions Of High School Students. *Journal of Agricultural Education*, 43(2), 56-67.
- BPS Jawa Tengah. (2015). Berita Resmi Statistik BPS Provinsi Jawa Tengah No. 56/08/33 Th.IX, 3 Agustus 2015: Produksi Cabai Besar, Cabai Rawit, dan Bawang Merah Provinsi Jawa Tengah Tahun 2014.Retrieved from: http://jateng.bps.go.id/ website/brs\_ind/brsInd-20150803132917.pdf
- Çepni, S., Hall Iloglu, A., Kocaman, S., & Aydın, S. (2011). The Evaluation of The Effectiveness of The Agricultural Module Supported with Worksheets on The Students' Conceptual Development. *African Journal of Agricultural Research*, 6(7), 1862-1875.
- Coletta, V. P., A.Phillips, J., & Steinert, J. J. (2007). Interpreting force concept inventory scores: Normalized gain and SAT scores. *Physical Review Special Topics - Physics Education Research, 3*(1), 010106-1-010106-5.
- Ergül, R., Simsekli, Y., Calis, S., Özdilek, Z., Göçmençelebi, S., & Sanli, M. (2011). The Effects of Inquiry-Based Science Teaching of Elementary School Students' Science Process Skills and Science Attitudes. *Bulgarian Journal of Science* and Education Policy, 3(1), 48-68.
- Erina, R., & Kuswanto, H. (2015). Pengaruh Model Pembelajaran Instad terhadap Keterampilan Proses Sains dan Hasil Belajar Kognitif Fisika Di SMA. *Jurnal Inovasi Pendidikan IPA, 1*(2), 201-2011.
- Hake, R. R. (1998). Interactive-engagement vs Tradi-

tional Methods: A Six-Thousand-Student Survey of Mechamics Test Data for Introductory Physics Courses. *American Journal of Physics (Am. J, Phys.), 66*(1), 64-74.

- Hake, R. R. (2007). Six Lessons From The Physics Education Reform Effort. *Lat. Am. J. Phys. Educ, 1*(1), 24-31.
- Healey, M., & Jenkins, A. (2000). Kolb's Experiential Learning Theory and Its Application in Geography in Higher Education. *Journal of Geography*, 99(5), 185-195.
- Khusniati, M. (2014). Model Pembelajaran Sains Berbasis Kearifan Lokal dalam Menumbuhkan Karakter Konservasi. *Indonesian Journal of Con*servation, 3(1), 67-74.
- Knobloch, N. A., Ball, A. L., & Allen, C. (2007). The Benefits of Teaching and Learning About Agriculture in Elementary and Junior High Schools. *Journal of Agricultural Education*, 48(3), 25-36.
- Mabie, R., & Baker, M. (1996). A comparison of experiential instructional strategies upon the science process skills of urban elementary students. *Journal of Agricultural Education*, 37(2), 1-7.
- Machin, A. (2014). Implementasi Pendekatan Saintifik, Penanaman Karakter dan Konservasi Pada Pembelajaran Materi Pertumbuhan. Jurnal Pendidikan IPA Indonesia, 3(1), 28-35.
- Marjan, J., Arnyana, I. P., & Setiawan, I. N. (2014). Pengaruh Pembelajaran Pendekatan Saintifik Terhadap Hasil Belajar Biologi dan Keterampilan Proses Sains Siswa MA Mu'allimat NW Pancor Selong Kabupaten Lombok Timur Nusa Tenggara Barat. e-Journal Program Pascasarjana Universitas Pendidikan Ganesha, 4(1), 33-40.
- Nana, S. A., & Salamah, Z. (2014). Pertumbuhan Tanaman Bawang Merah (Allium cepa L.) dengan Penyiraman Air Kelapa (Cocos nucifera L.) Sebagai Sumber Belajar BiologiSMA Kelas XII. JUPEMASI-PBIO, 1(1), 82-86.
- Özgelen, S. (2012). Students' Science Process Skills within a Cognitive Domain Framework. *Eurasia Journal of Mathematics, Science & Technology Education, 8*(4), 283-292.
- Pratiwi, Y. I., Budiharti, R., & Ekawati, E. Y. (2014). Pengembangan Media Pembelajaran IPA Terpadu Interaktif dalam Bentuk Moodle untuk Siswa SMP pada Tema Matahari sebagai Sumber Energi Alternatif. Jurnal Pendidikan Fisika, 2(1), 26-30.
- Putri, R. H., & Watemin. (2014). Analisis Trend dan Estimasi Harga Bawang Merah di Kabupaten Banyumas Periode Januari 2008 –Desember 2017. Jurnal Dinamika Ekonomi & Bisnis, 11(1), 65-69.
- Rahayu, E., Susanto, H., & Yulianti, D. (2011). Pembelajaran sains dengan pendekatan keterampilan proses untuk meningkatkan hasil belajar dan kemampuan berpikir kreatif siswa. Jurnal Pendidikan Fisika Indonesia (Indonesian Journal of Physics Education), 7(2), 106-110.
- Rauf, R. A., Rasul, M. S., Mansor, A. N., Othman, Z.,

& Lyndon, N. (2013). Inculcation of Science Process Skills In A Science Classroom Asian Social Science. Asian Social Science. *Asian Social Science*, 9(8), 47-57.

- Sheeba, M. N. (2013). An Anatomy of Science Process Skills in The Light of The Challanges to Realize Science Instruction Leading to Global Excellence in Education. *Educationia Confab*, 2(4), 108-123.
- Sugiyono. (2012). Metode Penelitian Kombinasi (Mixed Methods). Bandung: Penerbit Alfabeta.
- Sujarwanta, A. (2012). Mengkondisikan Pembelajaran IPA dengan Pendekatan Saintifik. Jurnal Nuansa Kependidikan, 16(1), 75-83.
- Sumarni, N., Rusliani, R., Basuki, R., & Hilman, Y. (2012). Respon Tanaman Bawang Merah terhadap Pemupukan Fosfat pada Beberapa Tingkat Kesuburan Lahan (Satus P-Tanah). J. Hort, 22(2), 130-138.
- Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). Intructional Development for Training Teaching of Exceptional Children. Broomington: Indiana University.
- Wahyudin, M., Maksum, M., & Yuliando, H. (2015). Dampak Kebijakan Pembatasan Impor Bawang Merah terhadap Usahatani Bawang Merah Di Kabupaten Probolinggo. Agritech, 35(3), 347-352.
- Wardani, S., Widodo, A. T., & Priyani, N. E. (2009). Peningkatan Hasil Belajar Siswa melalui Pendekatan Keterampilan Proses Sains Berorientasi Problem-Based Instruction. Jurnal Inovasi Pendidikan Kimia, 3(1), 391-399.
- Widoyoko, S. E. (2012). Teknik Penyusunan Instrumen Penelitian. Yogyakarta: Pustaka Pelajar.
- Wijayanti, A. (2014). Pengembangan Autentic Assesment Berbasis Proyek dengan Pendekatan Saintifik untuk Meningkatkan Keterampilan Berpikir Ilmiah Mahasiswa. Jurnal Pendidikan IPA Indonesia,3(1) 102-108.
- Wilujeng, I., Setiawan, A., & Liliasari. (2010). Kompetensi IPA Terintegrasi melalui Pendekatan Keterampilan Proses Mahasiswa S-1 Pendidikan IPA. *Cakrawala Pendidikan*, 29(3), 353-364.
- Yanti, I. W., Suciati, & Ariyanto, J. (2013). Pengaruh Model Science Technology Society Disertai Teknik Mind Map terhadap Hasil Belajar Biologi dan Sikap Peduli Lingkungan Siswa di Sman Colomadu. *Pendidikan Biologi*, 5(1), 115-128.
- Yeni, G. F., Putra, A., & Hufri. (2015). Pengaruh Handout Berorientasi Pendekatan Saintifik Terhadap Hasil Belajar IPA-Fisika Siswa Kelas IX SMP Pertiwi 2 Padang. *Pillar Of Physics Education*, 5(1), 97-104.

JPII 5 (1) (2016) 31-37



Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# COMPARISON OF STUDENTS' SCIENTIFIC LITERACY IN INTEGRATED SCIENCE LEARNING THROUGH MODEL OF GUIDED DISCOVERY AND PROBLEM BASED LEARNING

## D. Ardianto\*, B. Rubini

University of Pakuan, Indonesia

DOI: 10.15294/jpii.v5i1.5786

Accepted: 2 January 2016. Approved: 24 March 2016. Published: April 2016

#### ABSTRACT

This study aims to describe the comparison of students' scientific literacy improvement in integrated science learning through guided dicovery and problem based learning models. The subjects were 8th grade students of State Junior High Schools in Bandung. This research design was quasi-experimental with non randomaized static group pretest-posttest design. The instrument used in this study was multiple choice test and attitude scale. The result shows that the improvement of scientific literacy achievement of students who learned integrated science through guided discovery and problem based learning models did not differ significantly. Integrated science learning through guided discovery models can improve student literacy achievement with the gain of 0.37 (medium category), while by using problem based learning model can improve scientific literacy with the gain of 0.41 (medium category). It can be concluded that the both models of guided discovery and problem based learning can improve students' science literacy.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: guided discovery, integrated science learning, problem based learning, scientific literacy.

#### INTRODUCTION

The primary goal of science education curriculum is to provide an opportunity for learners to use their understanding of science in the public debate, make balanced information and decision about socioscientific issues affecting their life (American Association for the Advencement of Science, 2000). This thought underlied the idea of scientific literacy. Robert (in Dawson & Venville, 2009) explained that scientific literacy is the value of the students for life, regardless of the career and scientific needs. Individuals who are literate can be described in a practical way as being able to resolve the practical problems of health and survival; participate in debates and decision making in social practices; get motivated to find out that science is the product of human effort

\*Alamat korespondensi: Email: didit.ardianto@unpak.ac.id in cultural practices (Shen in Dawson & Venville, 2009). Christenson et al. (2013) refined the idea and considered that the scientific literacy was related to society preparation for the future to make of personal and collective decision on the socioscientific issue. Scientific literacy is considered as the root of the progressive change of science education (Sadler & Zadler, 2009).

The importance of science literacy in science education has been elaborated, therefore, scientific literacy has been recognized internationally as a benchmark of quality level of science education. The Program for International Student Assessment (PISA) consisting of developed industrialized countries (the Organization for Economic Cooperation and Development, OECD) responded by developing science literacy assessment for children aged 15 years and under. The assessment is also performed in countries that are volunteered to be assessed, including Indonesia. The further analysis results of the PISA data is for children in Indonesia resulted in several findings of:

- 1. The achievement of science literacy of students is low, with the average of 32% to the overall aspect, consisting of 29% for content, 34% for the process, and 32% for the context.
- 2. The diversity of students' scientific literacy among provinces in Indonesia is relatively low.
- 3. The ability to solve the problem of children in Indonesia is very low, and it is far behind countries such as Malaysia, Thailand, or Philippines.

The level of students' scientific literacy that is considerably low are caused by several factors. According to Hayat & Yusuf (2006), school learning environment and atmosphere affected students' literacy score variations. Other factors like school infrastructure, human resources and school organization and management also influenced significantly on students' literacy achievement. Firman (2007) also revealed that the low level of scientific literacy is closely related to the gap between applied science teaching in schools and the demand of PISA.

Based on the result of preliminary studies in one of the Junior High Schools in Bandung, it is revealed that teacher still teach science as a separated subject (chemistry, physics, biology), teacher still roles as the center of learning process (teacher center) so the the concept mastery and inquiry ability is rarely trained, teachers only focus on concept mastery and do apply discovery learning and problem-based learning. 40% of students are not being involved in finding the concept of science in learning process, 55% of students state that in learning process they are sometimes given the problems related to daily life, while 51% of students state that the science is taught separately (Chemistry, Physics, Biology). The preliminary study results into the basic assumption that science learning relevance at school is relatively low so it adversely affects the students' scientific literacy. Therefore, some efforts are needed to improve the quality of science teaching to improve students' scientific literacy.

Several previous studies have revealed about the development of scientific literacy in science learning in the classroom. Learning science using socioscientific issue is the learning approach that has important role in promoting scientific literacy (Sadler & Zadler, 2005). Sobard & Rannikmae (2011) revealed that learning by using socioscientific issue made students got difficulty in evaluating the evidence and make decision because of their critical thinking skills are relatively low. The development of critical thinking skills can be done through realistic and relevant learning to support scientific literacy competency domains (Bailin, 2002; Dam & Volmen 2004). Van Aalsvoort (in Sobard and Rannikmae, 2011) also stated that learning by using socioscientific issues that are relevant to the personal, social and global issues is necessary in developing students' scientific literacy. Moreover the development of scientific literacy can also be done through "writing tasks" in learning. Ritchie, et al. (2011) revealed that the students' involvement and interest in "writing tasks" can train basic skills of scientific literacy. In line with the Sadler (2004) research that said the essay on the socioscientific issue contributed effectively in the development of scientific literacy of middle school students.

Based on some of research results, the majority of scientific literacy development of students is performed by using socioscientific issues through learning process. However, in this article the researchers tried to explore the development of students' scientific literacy through integrated learning by using scientific literacy-based model. The model was guided discovery and problem based learning (PBL) models. Guided discovery model was selected for its inquiry in the learning steps. Inquiry steps was suitable to train competence / domain of scientific literacy. While, PBL model was selected because it was able to develop the students' critical thinking skills. Critical thinking skills are important aspects that affect students' literacy skills. The learning topics in this study was "Fluid" that was taught integratedly. The topic was presented to be relevant to the personal, social and global context. Fluid topic was divided into some subtopics consisting of blood pressure, stroke, the buoyancy of fish, and transportation in plants. This article revealed the achievements of students scientific literacy in science integrated learning using model of guided discovery and PBL.

#### **METHOD**

The method used in this research was quasi-experimental and the design was Non Randomaized Static Group Pretest-Posttest Design. The use of this design was intended to determine the effect of treatment towards the research subject (Fraenkel et al., 2012). The design can be seen in Table 1.

The research population was all students of State Junior High School in Bandung in the

academic year 2014/2015 and the subject was 70 students that were divided into two groups. The first group got integrated science learning using guided discovery model while the second group used PBL model. Instruments used in this research were the multiple choice questions used to assess students' scientific literacy skills in the aspects of the content and science competencies. The data obtained and dianalsisis quantitatively and qualitatively. Quantitative analysis was conducted on data of students' scientific literacy achievement scores of both whereas the observation of learning process was analyzed qualitatively.

 Table 1. Research Design of Non Randomaized

 Static Group Pretest-Postest Design

Group	Pretest	Treatment	Postest
Experiment I	T <sub>1</sub>	X <sub>1</sub>	T <sub>2</sub>
Experiment II	$T_1$	$X_2$	T <sub>2</sub>

Caption :

- T<sub>1</sub>: Pretest to determine initial achievement of students' scientific literacy
- X<sub>1</sub>: Science learning using guided discovery model
- X<sub>2</sub>: Science learning using problem based learning model
- T<sub>2</sub>: Postest to determine achievement of students' scientific literacy after treatment

#### **RESULT AND DISCUSSION**

Scientific literacy is defined as the ability to use scientific knowledge, to identify questions and draw conclusions based on the evidence, in order to understand and make decisions regarding to the nature and its changes resulted from human activity (Rustaman, 2003). In accordance with the definition, the test questions (items) require the use of science competency in the context by involving the application of scientific knowledge. Assessment of scientific literacy in PISA does not assess the context, but the competence, knowledge and attitude that are related with selected science contexts in the assessment. Therefore, this research assesses the achievements of scientific literacy in the aspect of knowledge, competence and science.

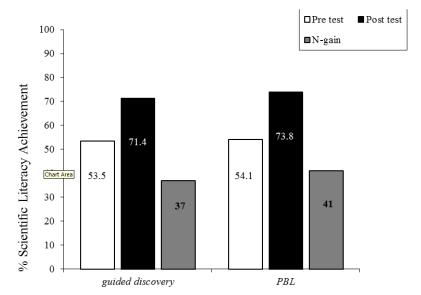
The treatment in this research was integrated science learning using guided discovery model for experimental group I and integrated science learning using problem based learning models for the experimental group II in four meetings. Tests was given in the first meeting before learning process and in the last meeting after learning process. Test materials were same for both tests, they consisted of 26 items of multiple choice questions. Overall achievements of students' scientific literacy who obtained science integrated learning using guided discovery and PBL models both before and after treatments were good (N = 80, p> 0.025), meanwhile the students' scientific literacy in the two groups improved 37% for guided discovery model and 41 % for PBL model.

Students' scientific literacy of both groups was well improved. However, after conducting difference test to the post test average of both groups, it was found out that there was no significant difference in students' scientific literacy skills (Figure 1). The result indicates that the implementation of guided discovery and PBL models in integrated science learning were able to be used in improving students' scientific literacy.

Improvements of scientific literacy aspects occured because of the integrated science lesson based on scientific literacy for both group could encourage students to construct and make connections between their knowledge and its application in daily life. This is consistent with Holbrook (2003) that stated "science will easily learned when the material is reasonable in students' point of view and also related to human life, interest and aspiration".

Implementation of integrated science learning by using guided discovery and problem based learning models also gave the opportunity to students to work together with other groups in doing the investigation, so that activity can develop their process and social skills. The collaboration between investigation and peer discussion can develop thinking and social skills. Vigotsky (in Ibrahim, 2012) said that social interaction occured between students and their friends can help to form new ideas and enrich their intellectual. He also said that if students interact with others who have better understanding, they will be able to achieve the level of development that is slightly above its actual capabilities.

The results also showed that the learning model of discovery and PBL provided opportunities for students to learn thinking analytically and try to solve their problems. This provides a positive impact on the thinking competence and students' understanding that will bring positive contribution to their sceintific literacy. This is in line with the results of several studies (Brickman, et al, 2009; Balim 2009; Alfiery 2011, and Nbina, 2013) which stated that learning proces that gives students the chance to be actively involved in gathering knowledge process in the deductive



**Figure 1.** Overall Students' Scientific Literacy. The difference test of score average showed no significant difference between groups using guided discovery and PBL models. (\*\*\* p > 0,025)

or inductive analysis can develop their thinking skills and cognitive ability, meanwhile the knowledge obtained will be more meaningful.

Scientific literacy that were examined consisted of knowledge and science competence. Analysis of scientific literacy knowledge conducted to determine the profile of Fluid material mastery. Fluid material is divided into several topics of blood pressure, abnormalities in the circulatory system, the buoyancy of fish and transportation in plants. Figure 2 shows the improvement of students' achievement for every content material that was discussed in the learning process. Overall, integrated science learning using guided discovery and PBL models can improve science content mastery achievement taught in the learning process. The highest improvement was in transportation of plant content of both groups that used guided discovery learning and PBL models. Results of students' activity observation showed that the dominant activity during the learning process with guided discovery and PBL models was in the experiment activities and teacher's explanation. This means that the experiment conducted by student contributed positively to students' understanding of this content. Through experiment, students were given the opportunity to discover the concept of transportation of plants. After the experimental activity was completed, the teacher also gave reinforcement in the concept of capillarity in plants through the video. The experiments conducted by students in both groups followed the steps in the scientific process so that it can help students master the concepts learned. This is in line with Swakk et al.

(2004) which states that learning using empirical cycle (the process approach) for example collection and classification of information, formulation of hypothesis, making predictions, interpretation of experimental results and making conclusions to improve and enhance the skills of inquiry and the students' cognitive processes; students were given the opportunity to learn thinking analytically and try to solve their problems.

The use of video in learning process was also considered easier for students to understand abstract concepts in transportation of plants material. The use of multimedia like video in learning process was able to improve the intensity of interactive communication, creative dialogue and students' discussion, thus triggering the formation of knowledge building in every students. The results of this study is consistent with Fan & Geelan (2012) which stated that the use of multimedia in science learning can enhance students 'understanding, science process skills and students' understanding of the nature of science. Those aspects are part of scientific literacy domain consisting of context, the competence of science and knowledge of science. Moreover, multimedia learning can contribute to the development of quality science learning and improve students' scientific literacy in the future. This study do not only reveal the students' understanding of fluid material, but the more interesting for us to observe is how is the students' thinking competence after obtaining science learning using guided discovery and PBL models. This is necessary because a person is said to be literate if he is not only proficient in conceptual terms, but also

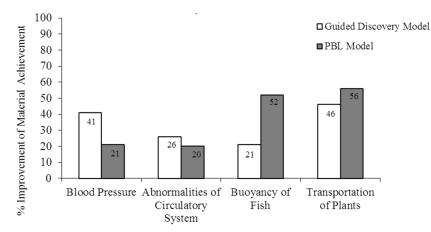
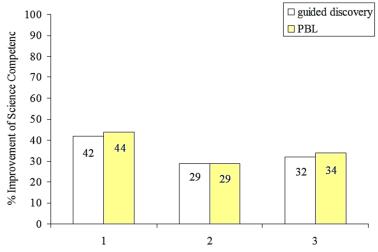


Figure 2. Profile of improvement content mastery achievement of fluid material after the learning process used Guided Discovery and PBL models



**Figure 3.** Improvement of students' science competencies after using guided discovery and PBL models in science learning (1. Identifying Scientific Issues; 2. Explaining Phenomena Scientifically; 3. Using Scientific Evidence)

their way of thinking to solve the problem using their knowledge. This research will be unfair if it only reveals of domain of content, therefore, the research results that will be subsequently discussed are science competence of students. Student competence revealed in this research refers to the scientific literacy indicators recommended by the Programme of International Student Assessment (PISA) in 2012. They are "Identifying scientific issues", "Explaining phenomena scientifically" and "Using scientific evidence". Overall performance shows improvement of students' science competencies after using guided discovery and PBL models in science learning can be seen in Figure 3.

Figure 3 shows that the achievement of students' science competencies overall showed encouraging results. The research revealed that the indicator of "identify scientific issues" improved 42% for guided discovery model and 44%

for PBL. Then for the indicator of "explaining scientific phenomena" it improved 29% for both models, and for the indicator of "using scientific evidence it improved 32% for guided discovery model and 34% for PBL.

The improvement of students' competence in each indicator was because the implemented learning model emphasized on students' independency and thinking skills. Basically, the model is applied in the classroom to give students an opportunity to practice recognizing authentic scientific issues in learning process to solve these problems through systematic stages. Hence students' scientific literacy skills of science process aspects has improved after implemented learning process. This is in line with research finding of Rubini et al. (2016) that revealed learning that facilitates students to solve problems can improve authentic domain process/students' competency significantly.

Moreover, the developed model is also supported with multimedia such as video, animation and film. The use of multimedia in learning process can motivate students to learn. The role of motivation developed from individual is very important the knowledge building depends on the students' motivation. The use of multimedia also can help students in learning process of the material that can not be seen directly in the classroom, for example the theory of the formation of the universe, the theory of the formation of the solar system, the movement of the planets in the solar system. This is consistent with the statement of Camberlain (2012) that stated the multimedia simulations in learning process can help students visualize objects and processes that can not be displayed directly in the classroom. Further it is explained that the availability of the technology allows students get richer learning experience during lesson through the use of simulation in the learning concept material.

Based on previous elaboration, the use of multimedia in learning process that shows the simulation gives an important role in the development of students' scientific competence. The result is consistent with several studies that reveal the use of interactive multimedia is potential in developing the scientific concepts and students' science process skill (Evan, Yaron and Leinhadt, 2008).

The implementation of integrated science learning using guided discovery and problem based learning model can improve students' scientific literacy skills both aspects of content and science competency in the medium category. This is influenced by several factors of (1) the big number of students so it took too much time to help them find a concept or problem solving, (2) integrated science learning required students to understand the concepts of various disciplines, students who were not familiar with that would have difficulty in linking concepts across disciplines, (3) during the learning process with guided discovery and problem based learning models students are required to act like a scientist, it was difficult for less intelligent students because they had to think or express the relationship between conceptual concept, which in turn leading to frustration, (4) students were also not familiar with the provided worksheet, because it required to do simple research that required mindset readiness then students who were not familiar with these conditions can experience the boredom, (5) goals and objectives of guided discovery learning can be disrupted by students and teachers who were familiar with traditional teaching method.

#### CONCLUSION

Based on the analysis it can be concluded that the integrated science learning using guided discovery and PBL model can be used to build students' scientific literacy in both aspects of content and science competency. The achievement of content mastery and students' science competency in both groups after learning process has improved quite satisfactory, this is because the learning (both guided discovery and PBL) is designed by adopting scientific approach methods, prioritizing independent learning, and promotes students' thinking skills. While the role of the multimedia in learning process facilitate students to understand abstract concepts.

From the research results, the science learning in junior high school should provide inquiry skills to students. If the student has been trained with the activities of inquiry, it can facilitate teacher in implementing integrated science learning using guided discovery and problem based learning model. This study was not used the authentic assessment in revealing students' scientific literacy skills. Therefore, if you intend to conduct similar research it is necessary to develop an authentic assessment to reveal students' scientific literacy skills.

#### REFERENCES

Alfieri, L., Brooks, P.J. & Aldrich, J.N. (2011). Does Discovery-Based Instruction Enhance Learning?. *Journal of educational Psycology*, (103) 1, 1-18.

American Association for the Advancement of Science. (2000). *Designs for science literacy*. Washington, DC: Author.

Bailin, S. (2002). Crithical Thinking and Science Education. *Science & Education*. 11: 361-375

Balim, A.G. (2009). The Effect Of Discovery Learning On Student's Success And Inquiry Learning Skills. *Eurasian Journal Of Educational Research*. (35): 1-20.

Brickman, P., Gormally, C., Armstrong, N & Hallar, B. (2009). Effects of Inquiry-Based Learning on Students'science Literacy Skills dnd Confidence. *International Journal for the Scholarship ofTeaching and Learning*. (3)2

Chamberlain. 2012. *Inquiry and Scientific Literacy*. Retrieved from www.sagepub.com/ upmdata/24393\_chamberlain\_chapter1.pdf date: 22 Februari 2016

Christenson, N., Rundgren, S.C., dan Zeidler, D.L. (2013). The Relationship of Discip-

Dam, G dan Volman, M. (2004). Critical Thinking as a Citizenship Competence: Teaching Strategies. *Journal Learning and Instruction*.14 (1), 359-379.

Dawson, V. & Venville, G. J. (2009). High-School Students' Informal Reasoning and Argumentation about Biotechnology: An indicator of scientific literacy?. *International Journal of Science Education.* 3(11), 1421–1445.

Fan, X., dan Geelan, D. (2012). *Effectiveness of active instruction with simulation on misconceptions in senior secondary physics classroom in Mainland China*. Paper presented at the 43rd Annual ASERA Conference, University of the Sunshine Coast.

Firman, H. (2007). *Laporan Analisis Literasi Sains Berdasarkan Hasil PISA NAsional*. Jakarta: Puspendik.

Fraenkel, J.R., Wallen, N.E. & Hyun, H.H. (2012). *How to Design and Evaluate Research in Education*. New York: McGraw-Hill.

Hayat, B., & Yusuf, S. (2006). *Benchmark Internasional Mutu Pendidikan*. Jakarta: Bumi Aksara

Holbrook, J., Laius, A., & Rannikmäe, M. (2003). *The Influence of Social Issue-Based Science Teaching Materials On Students' Creativity*. University of Tartu, Estonian Ministery of Education.

Ibrahim, M. (2012). *Pembelajaran Berbasis Masalah*. Surabaya: University Press.

Nbina, J. B. (2013). The Relative Effectiveness of Guided Discovery and Demonstration Teaching Methods on Achievement of Chemistry Students of Different levels of Scientific Literacy. *Journal of Research in Education and Society.* (4) 1, 8-13.

Ritchie, S.M., Tomas, L., &n Tones, M. (2011). Writing Stories to Enhance Scientific Literacy. *Internatonal Journal of Science Education*. 33(5): 685-707.

Rubini, Permana, & Ardianto. (2016). Membangun Literasi Sains Mahasiswa Non Sains dalam Perkuliahan IAD. Laporan Penelitian. Bogor: Pascasarjana Universitas Pakuan.

Rustaman, N.Y. (2003). *Literasi Sains Anak Indonesia 2000 dan 2003*. Bandung: Universitas Pendidikan Indonesia.

Sadler, T.D dan Zeidler, D.L. (2009). Scientific Literacy, PISA, dan Socioscientific Discourse: Asessment for Progressive Aims of Science Education. *Journal of science Teaching*, 1(1), 1-13.

Sadler, T.D., & Zeidler, D.L. (2005). The significance of content knowledge for informal reasoning regarding response to a sosiocientific issues: Applying genetics knowledge to to genentic engineering issues. *Journal of Science Education*. 89(1), 71-93.

Sadler, T.D. (2004). Informal reasoning regarding socioscientific issues: a critical review research. *Journal of Research in Science Teaching*, 41(5), 513-536.

Sobard, R., & Rannikmae, M. (2011). Assessing student's level of scientific literacy using interdisciplinary scenarios. *Science Education International*, 22 (2), 133-144.

Swaak, J., Jong, T.D., & Joolingen, W.R. (2004). The Effect of Discovery Learning and Expository Instruction on the Acquisition of Definitional and Intuitive Knowledge. Netherlands. *Journal of Computer Assisted Learning*, 20 (1), 225-234.



JPII 5 (1) (2016) 38-44

Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# INQUIRY-BASED SCIENCE COMIC PHYSICS SERIES INTEGRATED WITH CHARACTER EDUCATION

# D. Yulianti<sup>\*1</sup>, S. Khanafiyah<sup>2</sup>, S. Sulistyorini<sup>3</sup>

Universitas Negeri Semarang, Indonesia

DOI: 10.15294/jpii.v5i1.5787

Accepted: 8 January 2016. Approved: 25 March 2016. Published: April 2016

#### ABSTRACT

This study aimed to test the level of readability and feasibility of science comic, to knowcharacter development through a small test in some schools. The research design was Research & Development, trials were using quasiexperimental pre-test-post-test experimental design. The instruments to measure attitudes were: a questionnaire and observation sheet, a test used to measure comprehension of the material. The results showed that learning science by inquiry-based science comic can improvecharacters and cognitive achievement of primary school students. Results in the form of inquiry-based science comic can be utilized in learning science as a companion teaching materials.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: character, inquiry, science comic

## **INTRODUCTION**

The nation character is the basic needed to build a high level of civilization. People who are honest, independent, working as group, follow rules, trustworthy, strong and has a high work ethic, will produce a system of social life and well organized. Therefore Kemendiknas has launched a character-based education on May 2, 2010.

Teaching materials can be used to help both teachers and students in the learning process, so the teachers do not need too much presenting the learning materials in class. In theselection of the teaching materials, we need to pay attention to the illustrations effects that can be used to deliver messages to the users. One of the illustration form that being used frequently in teaching materials, namely comics or cartoons. Comics word comes from the English which is the main manifestation of the literary phenomenon of the image. The word comics generally accepted in Indonesia to mention literary images. According to Mc Cloud (2001), comics

\*Alamat korespondensi: Email: yulifis04@yahoo.com are drawings and other symbols are contiguous or adjacent in certain utterances which aims to deliver information and achieve aesthetic responses from readers. Comic is an art form that uses no moving pictures which are arranged in such forming and build up story. Science is a part of our lives and environment interaction is a central feature in the learning process (Sumaji, 2004). Physics is the science section which is a product and process, so that the learning can not be separated from the inquiry proceedings. Comic science in this study, is a series of illustrated stories that contain knowledge in the form of materials science subjects (physics) are arranged with everyday language and interesting.

Comics liked by the young to the old. Comics in addition to functioning as the entertainment media, can also be used effectively in order to raise interest in reading, develop vocabulary and reading skills and can be used as an effective medium for learning purposes (Hadi, 2008). The utilization of comics on learning in selected schools are to educate, excite learning, funny, and well known by children and adapted from their world. One media that can be used by teachers in the learning process of science (physics) is the science comics medium. Comics can also be used to increase interest. The research results by Yulianti & Khanafiyah (2009a) about the experiment of comic science of work and energy can increase the students' interest of Elementary School (SD) Susukan Semarang.Another research on the students of SD Negeri 2 Sukorejo Semarang (Yulianti et al., 2010) applying comic light material science, the result is the science students interest are growing. Therefore, the research on the character integration in science education is aided comic needs to be done.

The objectives of this research are: to test the legibility level and the feasibility of science comic through the medium test, small and class in a number of schools, to find the character development and cognitive learning outcomes after the application of teaching materials accompanying by Comics Science

#### **METHOD**

The study is conducting over two years, using a design research and development (Gall et al., 2003). Inquirybased science comic that has been validated testing experts and legibility and the feasibility of small groups consisting of 10 students, the group was composed of 20 students, and the class test on 8 elementary school. The study used a quasi - experimental, pretest-posttest with experimental design.

The subjects in this study are elementary school students from state schools and private elementary school in Semarang which consists of 16 districts. As the samples are from six (6) districts. The sampling is done randomly, we take 3 elementary school from each district consist of state school and a private elementary school. The research instruments consist of a questionnaire, the observation sheet and cognitive ability test. The data analysis has been done with N gain testscore. Themethod used in this research is quantitative method in the form of pre-post test.

#### **RESULTS AND DISCUSSIONS**

There are five kinds of science comic with the subject matter such asSubstance and Changing Form; Earth and the Universe; Thermal Energy and Sound Energy; Simple air; and Water RecyclingProcess. Science comic which being develope are series of illustrated stories that explain the material science subjects (physics). The students are invited to get to know the characters in the comics, understand the story with the help of an attractive image and some simple experiments. These comics are equipped with several sections such as pictures and illustrations that support the explanation of the material presented.

According to Waluyanto (2005), comic is a tool that has the function to convey the message. Comics as a medium, conveying the message in a clear, coherent, and fun ways. Comic as a media hasa potential to become a teaching material. Display image will help in understanding the material. Based on research by Yulianti et al. (2010) science learning by playing while learning approach can improve student learning outcomes. The "Playing While Learning" is a simple trial activities related to the material studied and invites students to do experiment by following the instructions. In the science comic there are also comic reading "Further With Science" for students to learn more about science. This section invites students to open up wider horizons so that its presentation in the form of material enrichment. The final part of this comic is the "Evaluation" which contains questions to test students' understanding of science presented in comics in the form of a game.Rice (2009) suggested that one of the learning process that can arouse the pleasure and interest is the addition of a game. The ana-

**Table 1.** The Results of Feasibility Analysis of Each Comics

Materials	Display	Language and Text	Content and Evaluation	Character Integrated	Average
Substances and Change	93	93	91	88	91,25 Very Reasonable
Earth and Universe	96	94	89	86	91,25 Very Reasonable
Heat Energy and Sound	98	91	88	85	90,5 Very Reasonable
Simple Air	99	90	87	87	90,75 Very Reasonable
Water Recycling Process	94	92	91	84	90,25 Very Reasonable
Average	96	92	89,2	86	90,8 Very High

lysis results of the feasibility average of comics produced is 90.80%. This shows that the use of Science Comic as a teaching material has a very high rate of viability. The results of the feasibility analysis are presented in Table 1.

The design of Science Comics is compiled using figures which appropriate for elementary school children with the balance and harmonious colors composition and the depiction of the situation with captions that help them to understand the material. This is in accordance with the stages of cognitive development according to Piaget, children of elementary school age who are in the age range 7-11 years are on the stage of concrete operations. Concrete operations stage has the characteristic ability to think logically, begin to look at the object objectively and conceptually, and the thought is no longer about themselves but the outside of themselves too(Trianto, 2007). The Science Comics are a merger between text and image, thus making the message looks more concrete.

Aspects of language and text in science comics are arranged using Bahasa Indonesia in accordance with formal spelling, communicative, adjusted text size, the sentence structure is quite short and easy to understand. Based on the aspects of language, good teaching materials have several criteria: appropriate with the mind development, understandable message and language, the usage of standard terms, and integrity of meaning in both sentences and paragraphs (Ministry of National Education, 2010).

The material aspect of science comics containsvalid and up to date illustrations of facts or physics concepts adapted to the curriculum at elementary science lessons. The materials are sufficient to achieve basic competences, as well as balance between content and exercises. This is in accordance with the Ministry of Education (2010) which states that the principles of the content of teaching materials cover the proportionality of relevance principle, adequacy and accuracy. Science comicsare constructed upon inquiry-based storyline. Science comics are also prepared based on guided inquiry. This is consistent with the research by Taulina et al. (2009) that adoption of inquiry approach to learning can improve thinking ability and activities of elementary school students. The application of guided inquiry approach is tailored to the intellectual development of students.

Readability test for the science comics was conducted using jumbled text as the instrument and performed on fourth grade students. The readability score of science comicwas 91.4% according to Bormuth criteriawhich states that teaching materials are easy to understand (Widodo, 2001). The science comic is understandable since it is modified into children's intellectual development level. It used communicative fonts while the size were varied between 15 to 12. The use of the varied font size aimed to attract students to read it. In the early part text size was set at 15 and ended at 12. This is true as stated by Schounnell cited in Kustiono (2010)that when students read, they should be given a larger size at the beginning, and later the teacher can decrease the size down to 12. The development of character and cognitiveof students before and after the study are presented in Table 2.

At each treatment, student's character was improved, though not all of the characters became custom. This is consistent with Lickona who states that there are three stages of character development; Moral Knowing, Moral Feeling, and Moral Action. Setyawati et.al (2013) believes that the utilization of science module is effective in improving students' character. Character development is presented through dialogue, depictions of figures and indicators adapted to the character as proposed by Ministry of Education. Ulfah (2004) finds that moral attitude or character of elementary school students can be developed using transparency comic as a graphic media.

Character development is delivered through the knowledge of indicators of comic characters favored by the reader. According to Damaiwati (2007), the comic medium is a form of teaching media. Acomic is likeable reading

Character	Before	Criteria	After	Criteria	Gain	Criteria
Religious	69,56	Start to develop	84,27	Being a custom	0,31	Average
Creative	62,84	Start to develop	85,50	Being a custom	0,35	Average
Curiosity	67,15	Start to develop	86,54	Being a custom	0,41	Average
Willingness to read	66,43	Start to develop	83,01	Being a custom	0,35	Average
Caring to nature	65,66	Start to develop	84,27	Being a custom	0,32	Average
Discipline	77,39	Start to develop	82,16	Being a custom	0,21	Low

Table 2. Analysis of Students' Character Development

resource for almost all age groups; children, adolescents and adults. Sewell & College (2003) states that the cultivation of character can be integrated into school life so that it becomes culture. Character development can also happen due to inquiry, since the science comic in this study was designed with the inquiry nuancewith playing approach. Inquiry can facilitate students to solve problems through scientific investigation, so that students can find their own answers (Mc Dermott et al, 1996). This is also found by Suma (2010), which explains that the inquiry-based learning is effective in increasing mastery of the material and scientific reasoning. Wiyanto study (2004) showed that the application of the inquiry approach successfully increasing interest, developing scientific abilities e.g. explaining, predicting, designing experiments, collecting, analyzing anddrawing conclusions, and communicating. Wenning (2005) discovered that the inquiry-based learning gives students experience in working scientifically.

Religious indicator presented in the comic through several dialogues and depictions of figures which recognize God and appreciate all natural phenomena as God's creation. Cognitive aspect of religious character that appears in the comics was emphasized through a dialogue which stated that the earth and the universe were formed because of God's Will. Affective aspect was brought via a dialog contains admiration toward God's creation while reminding others to always be grateful for all God's gifts. The conative aspectwas raised in the dialogue between characters who are grateful for everything and use them well. Religious is obedient attitudes and behaviours in carrying out the teachings of his religion (Ministry of National Education, 2010).

Discipline character was taught in the form of dialogue and depictions of figures who behave in an orderly and adhere to the rules. Cognitive aspect of disciplineappeared in comics through dialogue and depictions of figure stated that being on time is part of the discipline. Affective aspect was performedvia one of the characters that reminded others not to come late again. Conative aspect emerged when one of the characters promised to not be late again. Discipline is an act that shows orderly behaviour and complies with various rules and regulations (Ministry of National Education, 2010).

Creative characterpopped up whena character stated that use a simple technology facilitate the work of man. Affective aspect implied when the dialogue was able to raise readers' curiosity. Creative is thinking and doing something to generate new ways or result of something they have (Ministry of National Education, 2010).

Caring toward nature came out when the charactersaid that the drought was a result of human activity. Affective aspect was shown when the character concerned with the drought. Conative aspect rosein the case of one of the character said that he will participate to lessen drought. Caring for environment is the attitude and action which seeks to prevent damage to the surrounding natural environment, and develop measures to repair the environmental damage that has occurred (Ministry of National Education, 2010).

Students couldlearn the good attitude through character depiction. This is in accordance with Suyadi (2013), which explains that character education is a conscious and planned effort to determine the truth or goodness, love and do it in daily life.

In addition to character development through comics, the teacher gave an example directly to the students about the character that needed to be developed, e.g.coming on time, greeting others, praying before and after lessons, discipline in doing the task, and inviting students to pick up the garbages around them after the class ended. Direct example were meant that studentscould mimic them well. This is supported by Zarkasyi cited in Mulyatiningsih (2010) that to providing exemplary is capable of changing students' characters.

Development of the religious character was in the criteria of becoming a custom. This is because the indicatorsof character such as admiration at God's creation, being grateful to God werecharacterswhich had already existed in children. Azwar (2012) believed that the attitude or character is not only determined by the state of the object at hand but also related to the previous attitude experience. Moreover, the religious character was also developed through other subjects such as Islamic education and citizenship education.

The character of caring toward environment, creative and discipline began to develop. These were because the character indicators such as discipline in doing the task, following the school rules, creating a new sentence of a word, or greening school grounds, as well as participating in cleaning school were not the character that waseasily done by elementary school children. Elementary age is an age that is more playful and more inclined to break the rules, while not all elementary school children have high creativity to solve problems and littering became the obstacles to cultivate the good characters. This is supported

Statement	Before	After
Highest Score	85	95
Lowest Score	30	43
Means	60	74
<g></g>	0,34	
Statement <g></g>	Average	

Table 3. Means of Cognitive Learning Results Assisted with Science Comics

by Azwar (2012) that the culture in which we live and grew up to have a major influence toward the manifestation of our attitude.

The increased religious character, creative, lovereading and caring for the environment were in the average criteria since the interaction was limited to the classroom environment. The little time used in the study also led to a modest increase, but at the end of the study the development of characters shifted to "start tobecome a custom" criteria. This occured because changing characterstakes a long and gradual time (Wibowo, 2012). The process of developing character is a long process starting from start until the end of educational units. The development of character education is sustainable, which means starting from the beginning to the end of the education units (Ministry of National Education, 2010).

Improving disciplinary was low, but in the end it showed criteria of 'becoming a custom'. In addition, character is a developmental educational material. Developmental educational materials means that it requires quite a long process and strengthens the learning activities toward other learning activities, and between learning in the classroom with curricular activities at school and outside of school (Ministry of National Education, 2010).

#### **Cognitive Learning Result**

Cognitive learning outcomes are presented in Table 3. Scores were obtained from the tests given before and after the application of science comics.

Table 3 shows that the increase of cognitive learning before and after utilizing the science comicwas in the moderate category. This was due to the use of interesting and character integrated teaching materials in the form of comics, causing the students to be more interested in learning. Lubana et al (2013) suggest that the learning device oriented on character education has an effect on the cognitive learning. Novianti & Syaichudin (2010) adds that learning to use the medium of comics can increase students' understanding.

Bryan (2005) concluded that the character is not only included in the curriculum but can be applied in students' life anytime. Integration of the characters aimed to promote characters education through learning activities. Song et al. (2008) thinks that comics can be used as a powerful learning media to interpret the knowledge and application of science, because the use of comics in science learning will be more stimulating and interesting than sole explanation of science facts. Beside that, cognitive learning outcomes after the use of science comic in learning increase significantly. Wahyuningsih (2011) said that comic as medium of learning can improve learning outcomes completeness, liveliness, interest and positive response from students.

Benninga, et al (2003) suggested that schools which handle their character education program seriously tend to have high academic achievement scores. This is in line with the opinion of Tatman et al. (2009) which states that a school that integrates character education in learning untilbecoming habit, the students would have high cognitive learning outcomes. This is consistent with the results of research by Yulianti & Khanafiyah (2009b) on the tryout of force and energy science comic to increase students' interest at Susukan elementary school Semarang. Yulianti et al. (2010) stated that the application of science comics can foster interest in science toward students of SD N 2 Sukorejo Semarang. Reading is a form of passive play, and through play children have the opportunity to explore, discover, express, create, and learn pleasantly.

### **CONCLUSION**

Based on this research, it can be concluded as follows: the results of the feasibility and readability test of science comic could be used as teaching materials and improve the character and the cognitive learning of elementary school students. Thus inquiry-based science comics that had been generated could be used widely in science teaching as a companion of teaching materials, in addition to using instructional media that had been used.

Recommendation was addressed to teachers and parents to take advantage of a companion teaching materials in the form of comics in addition to teaching materials that had been used, to improve the character of the students. The use of comics should be repeated at home so that character development could take place quickly.

# ACKNOWLEDGEMENTS

Thanks to the Chairman of the DIKTI through the Community Research and Service of Semarang State University which has provided an opportunity to obtain funds through the Decentralization Program Competitive Grants

#### REFERENCES

- Azwar, S. (2013). Penyusunan Skala Psikologi. Yogyakarta: Pustaka Pelajar
- Benninga, J. S, Berkowich, M.W, Kuehn, P & Smith, K. (2003). The Relationship of Character Education Implementation and Academic Achievement in Elementary School. *Journal of Research in Character Education*, 1(1), 19-23.
- Bryan,L. (2005). A Grimm Approach to Character Education. Journal of Social Studies Research, 29(1), 3-6.
- Kementerian Pendidikan Nasional Badan Penelitian Dan Pengembangan Pusat Kurikulum. 2010. Pengembangan Pendidikan Budaya Dan Karakter Bangsa. Jakarta
- Kustiono. (2010). Media Pembelajaran-Konsep, Nilai Edukatif, Praktek Pemanfaatan dan Pengembangan. Semarang: UNNES PRESS.
- Lubana, L. APB Prasetyo., & E. Cahyono. (2013). Pengembangan Perangkat Pembelajaran Biologi Berbasis Kasus dan Berorientasi Pendidikan Karakter. Journal of Innovative Science Education, 2(1), 1-7.
- Mc Cloud, S. (2001). Understanding Comic. Jakarta: Kepustakaan Populer Gramedia.
- Mc. Dermott, L.C. (1996). A Perspective on Teacher Preparation in Physics and Other Sciences : The Need for Special Cource for Teacher. *American Journal of Physics*. 58(8), 734-742.
- Mulyatiningsih, E. (2010). Analisis Model-model Pendidikan Karakter Untuk Usia Anak-anak, Remaja dan Dewasa. Jurnal penelitian Pendidikan, 10(1), 74-85.
- Novianti, R. D. & M. Syaichudin. (2010). Pengembangan Media Komik Pembelajaran Matematika untuk Meningkatkan Pemahaman Bentuk Soal Cerita Bab Pecahan pada siswa Kelas V SDN Ngembung. *Jurnal Teknologi Pendidikan*, 10(1), 74-85.
- Rice L. 2009. Playful Learning. Journal for Education in the Built Environment, 4(2), 94-108.

- Setyawati, R. Parmin. & A. Widyatmoko. (2013). Pengembangan Modul Ipa Berkarakter Peduli Lingkungan Tema Polusi sebagai Bahan Ajar Siswa SMKN 11 Semarang. Unnes Science Education Journal, 2(2), 245-253.
- Sewell & College. (2003). Teacher's Attitudes Toward Character Education and Inclusion in Family and Consumer Science Education Curriculum. *Journal of Family and Cosumer Science Education*, 21(1), 11-17.
- Song, Y. Heo, M. & Krumenaker, L. (2008). Cartoons-An Alternative Learning Assessment. *ProQuest Agriculture Journals*, 31(5), 16-24.
- Suma, K. (2010). Efektivitas Pembelajaran Berbasis Inkuiri dalam Meningkatkan Penguasaan Konten dan Penalaran Ilmiah. Jurnal Pendidikan dan Pengajaran 43(6), 47-55.
- Sumaji. (2003). Pendidikan Sains Yang Humanistis. Yogyakarta: KANISIUS.
- Suyadi. (2013). Strategi Pembelajaran Pendidikan Karakter. Bandung: Rosda.
- Tatman, R. Edmonson, S & Slate, J. (2009). Character Education-A critical Analysis. International Journal of Educational Leadership Preparation, 4(4), 8-16.
- Taulina, D. Zubaidah, S & Mahanal S. (2009). Penerapan Metode Inkuiri Dipadu Dengan Reciprocal Teaching Pada Mata Pelajaran Sains Untuk Meningkatkan Kemampuan Berpikir dan Aktivitas Siswa Kelas V Madrasah Ibtidaiyah Wahid Hasyim III Malang. Jurnal Cendekia. 2(1), 11-22
- . Trianto. (2007). *Model Pembelajaran Terpadu dalam Teori dan Praktek*. Jakarta: Prestasi Pustaka.
- Ulfah, M. (2004). Efektivitas Pembelajaran Dengan Media Panggung Boneka dan Komik Transparansi Dalam Membentuk Sikap Moral Siswa SD. Jurnal Pendidikan Dasar, 5(1), 11-21.
- Wahyuningsih, AN. (2011). Pengembangan Media Komik Bergambar Materi Sistem Saraf Untuk Pembelajaran Yang Menggunakan Strategi PQ4R. Jurnal Nasional, 1(2), 109-117.
- Waluyanto. H.D. (2005). Komik Sebagai Media Komunikasi Visual Pembelajaran. Jurnal Nasional, 7(1), 45-55.
- Wenning, C.J. (2005). Implementing inquiry-based instruction in the science classroom: A new model for solving the improvement-of-practice problem. *Journal of Physics Teacher Education*, 2(4), 7-14.
- Wibowo, Agus. (2012). *Pendidikan Karakter*. Yogyakarta: Pustaka Belajar.
- Widodo, T. (2001). *Modifikasi Tes Rumpang untuk Bahan Ajar MIPA*. Semarang : Lembar Penelitian UNNES.
- Wiyanto. (2004). Kegiatan Laboratorium IPA untuk Mengembangkan Kemampuan Berpikir. Prosiding Makalah Konvensi Nasional Pendidikan Indonesia (Konaspi) V di Surabaya, 9 Oktober 2004. ISBN: 979-445-001-4
- Yulianti D & Khanafiyah S. (2009a). Uji Coba Pembua-

tan Komik Sains Materi Usaha Energi Untuk Meningkatkan Minat Siswa SD Susukan Semarang. Laporan Penelitian. Semarang:LP2M Unnes.

-----. (2009<sup>b</sup>). Penerapan*Komik Sains* Materi Cahaya Untuk Meningkatkan Minat Siswa SD Negeri 2 Sukorejo Semarang.Laporan Penelitian. Semarang:LP2M Unnes.

Yulianti, D ; Wiyanto & Dewanti, S.S. (2010). Model Pembelajaran Sains di Taman Kanak-Kanak dengan Bermain Sambil Belajar. Jurnal Ilmu Pendidikan. 17(6), 434-438. JPII 5 (1) (2016) 45-50



Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# THE APPLICATION OF INQUIRY LEARNING MODEL TO IMPROVE "SATU ATAP" STUDENTS' LEARNING RESULTS AT SMPN 4 SINGOSARI MALANG

B. Setiawan\*1, T. Sunarti<sup>2</sup>, D. Astriani<sup>3</sup>

<sup>1,3</sup> Prodi S-1 Pendidikan IPA Unesa, <sup>2</sup>Jurusan Fisika Unesa Fakultas Matematika dan Ilmu Pengetahuan Alam Unesa, Surabaya, Indonesia

DOI: 10.15294/jpii.v5i1.5788

Accepted: 8 January 2016. Approved: 26 March 2016. Published: April 2016

## ABSTRACT

The implementation of the learning device with inquiry learning model into a developed model and tested in the learning process in elementary and junior high school "Satu Atap" 4 Singosari Malang. This type of research is done through experimentation with pre-experimental design that is implemented by the design of one group pretest and posttest design. The trial results with the learning device guided by inquiry learning model at the elementary-SMPN 4 "Satu Atap" Singosari Malang shows that the activities carried out as many as four meetings run according to the lesson plans have been made. Learning by using inquiry model on electric material can be accomplished through: 1. Identification of question / formulate problem with the average score 3:38 (pretty good), step 2. Formulate a hypothesis with an average score of 3:25 (pretty good), step 3. Designing and observation/ experiment with an average score of 3:50 (well), step 4. Collecting and analyzing the data with an average score of 3:38 (pretty good), and step 5. Drawing conclusions/ generalizations with an average score of 3:38 (pretty good). Learning models for additives substance material with step 1. Identify the question / formulate the problem got an average score of 3:13 (pretty good), step 2. Formulate a hypothesis to get an average score 3:13 (pretty good), step 3. Designing and making observations / experiment with an average score of 3:38 (pretty good), step 4. Collecting and analyzing the data with an average score of 3:25 (pretty good), and step 5. Drawing conclusions / generalizations with an average score of 3:50 (well). The students' learning outcomes using inquiry learning model covers aspects of knowledge, skills and attitudes obtained as follows: the aspect of knowledge through the pretest and posttest on the matter of electricity has increased the average percentage score from 42.6 on the pretest become 67.7 with an average score of N-Gain 0.44 in the medium category, while the knowledge aspect of learning outcomes on additive substance material has increased the average percentage of the score from 42.6 to 82.2 in pretest and posttest with an average score of N-Gain 0.69 in the medium category. The skill aspects on electricity material get the highest score in the predicate B +, while the highest score of additive substance material on the predicate A-, as well as attitudes aspects shows that more than 50% students show a good attitude during the learning process, ie 67% on the electricity material and 80% on the additives substance material.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: Inquiry Learning Model, Science Learning Media, Students' Learning Outcomes

# INTRODUCTION

"Satu Atap" Elementary School - Junior High School (SD-SMP) is a different educational model of elementary and junior high schools be-

\*Alamat korespondensi: Email: benisetiawan@unesa.ac.id cause the implementation of teaching and learning process is in one place. This model is designed for educational institutions become closer to the most easily accessible by the society (Fadjri, 2009). We hope no longer school-age children who are not in school because of the distance to school. However, the quality of the education in

"satu atap" elementary and junior is still far from ideal, as happened in the SMPN "Satu Ata"" Karangploso Batu-Malang and SD-SMP "Satu Atap" Kokop Bangkalan village, none of the students is graduated in National Examination 2010. It shows that all subjects tested in National Examination including IPA, the students obtain low score or below the standard set by the government. One of the failure reason is the limitation of the human resources quality. This is consistent with the research results of Rahmasari, 2014 stating that the limiting factor in the implementation of elementary and junior high chool of "SATAP" is the number of teachers and education personnel are not adequate. In contrast to ordinary schools whose human resources are met in terms of both the amount and the minimum requirements, the student background, school facilities as well as the location and distance are relatively easy to reach. Therefore, we need a breakthrough in the process of learning science in "Satu Atap" elementary and junior high school in preparing the plan of learning process by the teacher. The empowerment of the teachers in "SATAP" elementary and junior high school should be done to overcome the obstacles in the implementation of schools' policies in the learning process (Rahmasari, 2014). In addition, the need to pay our attention to the lack of facilities in the school, for example, no media such as OHP, no internet facility and have not apply the inquirí learning model in the science subject in "Satu Atap" elementary and junior high school.

The inhibiting factor of the activities implementation in "SATAP" elementary and junior high school in addition to the lacking number of teachers and education personnel, inadequate facilities and infrastructure is also inadequate (Rahmasari, 2014). Muhafid, 2013 stated that one of the causes of have no science learning at "SATAP" schools because the teachers are from different disciplines and the limited learning device, media, and science learning resources for teachers and students.

Data from observations mention that the use of media-based IPA both manual and IT will greatly assist the process of students' concept understanding and can support student achievement (Science learning media especially about abstract concepts). From an interview with some teacher who teach at "SATAP" school, it revealed the problems arising from the teachers in the implementation process of learning science, namely the lack of facilities and infrastructure of the school. Another thing that is more important is to prepare the teachers in preparing a learning device and the media that support and implement the inquiry learning tools in the learning process that can improve students' skills in scientific processes that can improve student learning outcomes. According to Lee &Krapfl, 2002; Smolleck et al., 2006 in Nam (2011), Inquiry-based learning provides opportunities for students to internalize or transform the new information by which they construct their individual cognitive structures.

Results of other studies mention that the media model of DNA proved to be effective in teaching the concept of genetic material (Susantini, 2008). The same was reported, that the use of models of DNA, photographs and chromosome preparation can finish high school student learning objectives (Vebriari, 2010).

Science media and learning tools that will be developed need to pay attention to hands-on and minds on that needs to be equipped with the Student Activity Sheet (LKS) which can stimulate students' inquiry skills "Satu Atap" elementary and junior high school. The students will spend a lot of time in inquirí activities such as: observing, manipulating materials, and conduct an investigation. The learning objectives can be achieved if the inquiry involves students in identifying the problem, make hypotheses, predict the concepts and principles, designing experiments, discussion, analysis, and concluded.

"Problem solving therefore, a variety of instructional strategies should be included in one's teaching repertoire. To achieve the goal of science instruction based on open-inquiry, instruction should involve students in hypotheses testing (testing the predictions of concepts or principles) or problem solving (testing the solutions to problems). Open- inquiry instruction, such as problem solving or hypotheses testing, provides students" (Pizzini, 1991).

Science in an inquiry process is already listed in the Content Standards. The fact that happened in elementary and junior high school "Satu Atap" has minimum facilities, so inquiry skills are rarely trained. The problems which experienced by the teachers when teaching science with inquiry are the lack of media and the application to the learning process. According to Christina et al., 2006 states that a science teacher who first used the inquiry often fail in the learning process because teachers have not been able to understand the use of inquiry in the science learning.

Inquiry learning model is a model of learning which the student formulates the problem, designing experiments, collecting, analyzing data and make decisions all by themselves and must meet four criteria: clarity, appropriateness, accuracy, and complexity (Nugroho, 2012). Inquiry learning model is a type of learning that requires the students to process the message so they obtain the knowledge, skills, and values. In addition, the inquiry learning model is a series of activities that highlight the process of critical thinking and analysis to seek and find their own answer to the problem in question through 1) orientation, 2) formulate problems, 3) formulate hypotheses, 4) collect data, 5) test the hypothesis, 6) formulate conclusions (Rahayu, 2013). Inquiry learning model can develop a scientific thinking skill by placing students as learners to solve problems and acquire the knowledge of critical thinking so they can understand the concepts of science (Kurniawati, 2014).

Therefore, a research about the application of inquiry learning model with multiple science media to improve students' learning score through the worksheet needs to be done. Inquiry skills that are given to students including: formulating the problem, formulating hypotheses, designing and conducting experiments, and formulate conclusions or generalizations.

#### METHOD

The type of research used is experimental with pre-experimental design. The implementation scenarios are implemented through the design of one group pretest and Posttest Design (Dawson, 1997).

#### **RESULTS AND DISCUSSIONS**

The application result of the learning with inquiry learning model at the elementary-school SMPN 4 "SATAP" Singosari Malang regency consists of inquiry learning, the learning outcomes which consists of aspects of knowledge, skills and attitudes to learning.

#### **Inquiry Learning**

Inquiry learning in the electrical materials in class VI shows that the activities carried out as many as four meetings run according to RPP that have been made. At the activities core seen that the skills of inquiry, namely: 1. Identify the question / formulate the problem got an average score 3:38 (pretty good), step 2. Formulate a hypothesis to get an average score 3:25 (pretty good), step 3. Designing and making observations / experiment with an average score of 3:50 (well), step 4. Collecting and analyzing the data with an average score of 3:38 (pretty good), and step 5. Drawing conclusions / generalizations with an average score of 3:38 (pretty good). Learning outcomes in the form of a diagram is shown in Figure 1 below.

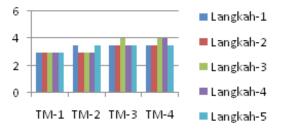
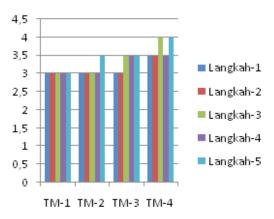


Figure1. The Results of Inquiry Learning In Electrical Material

Based on the above chart, inquiry learning outcomes categorized quite good to excellent from step 1 to step 5. Corebima (2010) state that inquiry-based learning is a teaching strategy that has the potential to empower the ability to think. Some research also suggests that the inquirybased research supported by media will enhance the skills and student learning outcomes, while the guided inquiry learning outcomes in the additive material shows that the activities carried out as many as four meetings run according to RPP that have been made. Consider the following two pictures.



**Figure 2.** The Results of Inquiry Learning about additives Materials

Based on the above chart, inquiry learning outcomes have good enough category from step 1 to step 5. The results of guided inquiry learning on material additives in class VIII indicates that the activities carried out as many as four meetings run according to RPP has been made, at its core activities appears that the skills of inquiry that is step 1. Identify the question / formulate the problems obtaining an average score of 3:13 with the category quite well, step 2. Formulate a hypothesis obtained an average score of 3:13 by category quite well, step 3. Design and conduct observation / experiment with an average score of 3:38 categorized quite good, step 4. Collecting and analyzing the data with an average score of 3:25 categorized quite good, and step 5. Drawing conclusions / generalizations with an average score of 3:50 categorized good.

Inquiry learning model in the matter of electricity and additives runs very effectively conducted on students from elementary and junior high school "SATAP", this is according to research from the Muslim (2011) which states that the results of inquiry learning in the material expansion goes very well with an average percentage of 95%, as well as according to Setiawan (2013) states that the learning process by using inquiry model can improve students' activities by 77.34% compared with 69.98% for conventional learning. It indicates that the inquiry learning model is suitable in science learning through the identification question / formulate the problem, formulate hypotheses, design and conduct observation / experiment, collecting and analyzing data, and draw conclusions / generalizations. Inquiry learning model can also help to improve the ability of students' science thinking process (Simsek, 2010).

#### Learning Outcomes

The learning result in electrical materials and additives include knowledge, skills and motorics through technical pretest and posttest. The study results can be seen in Figure 3.



**Figure 3a**. Learning Outcomes of Electrical Materials Knowledge of, **Figure 3b**. Learning Outcomes of Material Additive Knowledge

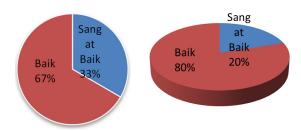
Based on the picture above, the learning outcomes aspects of electrical materials knowledge has increased on the average value from 42.6 into 67.7 with an average value of N-Gain score of 0.44 in the medium category, while the knowledge aspect of additive materials has increased the average value on the posttest from 42.6 to 82.2 with an average value of N-Gain score of 0.69 which is categorized as medium. This is supported by the research results by Maretasari (2012) which states that the inquiry learning

model can improve learning outcomes by 0,53 of the N-Gain and categorized well so can be concluded that the inquiry learning model has a significant impact on student learning outcomes. Other studies have shown that by using inquiry learning model, it has positive influence on the understanding of the concept as evidenced by the results of the students score an average of 9:50 to 18:55 (SimsekKabapinar P & F, 2010). Similar statement by Kurniawan, 2013 that the inquiry method can improve students' understanding of concepts and creativity of the students with the data in the form of classical values student achievement in the first cycle of 78.04% to 97.56% in the second cycle. Inquiry based learning approach that has a positive impact on student learning, because students are invited to work like scientists, given the experiences, making it easier for students understanding the material and the impact on the students' score is seen on the graph post-test.

Inquiry based learning is effective to increase the learning outcomes, the student enthusiasm in participating the practical activities, and the attitudes of students in learning. Based on the score of N-Gain acquired with category shows that the learning outcomes aspects of knowledge does not give much effect to the improvement from pretest to posttest, it is because the students from elementary and junior high school "SATU ATAP" 4 Singosari Malang are not familiar with the activities such as identified question / formulate the problem, formulate hypotheses, designing and observation / experiment, collecting and analyzing data, as well as draw conclusions / generalizations. Therefore we need the implementation of inquiry learning model on an ongoing basis, while the learning outcomes on electrical materials and additives substance using inquiry learning model can be seen in Figure 4.

Figure 4a and 4b show the ability of students to the skill aspect. In electrical material, the highest value on the predicate B +, while the highest value on additive material on predicate A-. This shows that there is a skill that have not mastered by students which is stringing a simple electrical tools, while at the material additives students can do better at the activities designed in LKS, so the results indicated that the students' skills in material additives is higher than the material electricity. The above results is in consequence to research from Jayadianta (2010) which states that the inquiry learning model can develop the ability of students' skills such as drafting tool skills by 65.62%, the skill to make charts trial in accordance with the guidelines of students' worksheet 46.87% and skills to determine solid objects by 100%, while the learning attitude in electrical materials and additives using inquiry learning model can be seen in Figure 5.

**Figure 4a**. The graph of students' skills learning outcomes of electrical material, 4b. The graph of students' skills learning outcomes of Additive material



**Figure 5a**. Graph of discipline attitude in electrical materials, 5b.Grafik discipline attitude in material additives.

Based on the chart above shows that over 50% of the student's attitude is good, ie 67% of electricity and 80% of the material in the material additives. The management attitude in elementary and junior high school, students' attitudes need to be developed so that can be better. This is in accordance with the psychological stages of students aged 12-14 years who are at times search of self recognition. According to Jayadianta (2010) states that the inquiry learning model can develop the ability of students' attitudes as it expresses the opinion of 71.87% and 65.63% of experimental work. Activities in inquiry learning can influence a positive attitude in learning science (Bayram, 2013).

# CONCLUSION

Based on the analysis and discussions, the following conclusions can be made, A. the process of learning by using Inquiry Learning model on electric material with step 1. Identify the question / formulate problem with an average score of 3.00 observations categorized quite good, step 2. Formulate hypothesis with an average score of 3.20 categorized quite good, step 3. Designing and observation / experiment with an average score of 3.60 categorized good, step 4. Collecting and analyzing the data with an average score of 3.70 categorized good and step 5. Drawing conclusions / generalizations.

For additives substance material using step 1. Identify the question / formulate the problem, step by an average score of 3.00 is quite good category 2. Formulate a hypothesis with an average score of 3.10 categorized as quite good, step 3. Designing and making observations / trial, a step with an average score of 3.30, consider as good enough category 4. Collecting and analyzing the data with an average score of 3.70 categorized as good., and step 5. Drawing conclusions / generalizations.

The students' learning outcomes using inquiry learning model covers aspects of knowledge, skills and attitudes, obtained as follows: the aspect of knowledge through the activities of pre-test and post-test on the material of electricity has increased the average percentage of the score from 42.6 to 67.7 with an average score of N-Gain Score 0.44 categorized as medium, while the knowledge aspect of learning outcomes on additive materials have increased the average percentage score from 42.6 to 82.2 with an average value of N-Gain score of 0.69 is categorized medium. The skills aspects in electrical material got the highest score on the predicate B +, while the highest score on additive material on the predicate A-. The aspects of attitudes shows that more than 50% students show a better attitudes, 67% in electricity and 80% of the substance additives material.

#### REFERENCES

- Bayram, Z. (2013). Effect Of Inquiry Based Learning Method On Students' Motivation. Procedia Social and Behavioral Sciences, 106, 988-996.
- Dawson, Thomas E. (1997). A Primer On Experimental And Quasi-Experimental Design. (Diakses di http://eric.ed.gov).
- Christina, V.S & Gwekwerere, Y.N. (2006). Using a Guided Inquiry and Modellling Instructional Framework (EIMA) to Support Preservice K-8 Science Teaching. *Wiley InterScience Journal*, 1 (2), 12-20, *DOI 10.1002/sce.20177*. (Diakses di www.interscience.wiley.com).
- Fadjri, M. (2009). Model Sekolah Satu Atap sebagai Implementasi dari Inovasi di Bidang Pendidikan. Jurnal Online. (Diakses tanggal 10 Juli 2015).
- Jayadianta, A.K. (2010). Penerapan Model Pembelajaran Inkuiri Untuk Meninhkatkan Pemahaman Tentang Peristiwa Benda Padat Dalam

Air Melalui Kegiatan Praktikum. *Jurnal Pendidikan Dasar*, 2 (1), 122-130. (Diakses di http:// file.upi.edu/direktori/jurnal/pendidikan \_\_dasar/ nomor\_13-April 2010).

- Kurniawan, A.D. (2013). Metode Inkuiri Terbimbing Dalam Pembuatan Media Pembelajaran Biologi Untuk Meningkatkan Pemahaman Konsep dan Kreativitas Siswa SMP. Jurnal Pendidikan IPA Indonesia, 3 (1) 112-121. (Diakses di http:// journal.unnes.ac.id/nju/index.php/jpii.
- Kurniawati, I.D, Wartono & Diantoro, M. (2014). The Effect Of Peer Instruction Integrated Guided Inquiry Learning On Concepts Acquisition And Critical Thinking of Students. Jurnal Pendidikan Fisika Indonesia, 10 (1), 36-46. DOI: 10.15294/jpfi.v10i1.3049. (Diakses di http://Journal.unnes.ac.id/nju/index.php/jpfi).
- Muhafid, E.A. (2013). Pengembangan Modul IPA Terpadu Berpendekatan Keterampilan Proses Pada Tema Bunyi di SMP Kelas VIII. Unnes Physics Education Journal, 1 (1), 33-40. (Diakses di http://journal.unnes.ac.id/sju/index.php/usej).
- Maretasari, E. (2012). Penerapan Model Pembelajaran Inkuiri Terbimbing Berbasis Laboratorium Untuk Meningkatkan Hasil Belajar dan Sikap Ilmiah Siswa. Unnes Physics Education Journal, 2 (1) 44-52. (Diakses di http://journal.unnes.ac.id / sju/index.php/upej).
- Muslim. (2011). Implementasi Inovasi Pembelajaran IPA Berbasis Inkuiri Untuk Menumbuhkembangkan Keterampilan Proses Sains dan Sikap Ilmiah Siswa Melalui Kegiatan Lesson Study. Jurnal Pengajaran MIPA UPI, 16 (2), 99-108.
- Nam, J. (2011). The Effect of a Collaborative Mentoring Program on Beginning Science Teachers' Inquiry-based Teaching Practice. *International Journal of Science Education*, 35 (5), 815-836.

- Nugroho, S, Suparmi & Sarwanto. (2012). Pembelajaran IPA Dengan Metode Inkuiri Terbimbing Menggunakan Laboratorium Riil dan Virtual Ditinjau Dari Kemampuan Memori dan Gaya Belajar. *Jurnal Inkuiri*, 1 (3), 235-244.
- Pizzini, E. L. (1991). The Inquiry Level Of Junior High Activities: Implications To Science Teaching. *Journal Of Research In Science Teaching*, 28 (2), 111-121.
- Rahayu, Sri. (2013). Pengaruh Penggunaan Model Pembelajaran Inkuiri Terhadap Hasil Belajar IPA. Jurnal Didaktika Dwijaya Indria, 2 (1), 123-133. (Diakses di http://jurnal.fkip.uns.ac.id/ index.php/pgsdsolo/article/view/4134).
- Rahmasari, E. (2014). Implementasi Kebijakan SD-SMP Satu Atap Di Desa Canggal Kecamatan Candiroto Kabupaten Temanggung. *Journal Universitas Negeri Yogyakarta*, 3 (5), 100-109. (Diakses di http://journal.student.uny.ac.id/ jurnal/artikel/9338/81/961).
- Setiawan, D & Buditjahjanto. (2013). Pengaruh Metode Pembelajaran Inkuiri Terhadap Ketuntasan Hasil Belajar Siswa Di SMKN 3 Buduran Sidoarjo. *Jurnal Pendidikan Teknik Elektro*, 2 (1), 12-20.
- Simsek, P & Kabapnar, F. (2010). The effects of inquirybased learning on elementary students' conceptual understanding of matter, scientific process skills and science attitudes. Procedia Social and Behavioral Sciences, 2, 1190–1194.
- Susantini, E. (2008). Efektivitas Model DNA dalam Meningkatkan Pemahaman Konsep Materi Genetika. Jurnal Penelitian Pendidikan Matematika dan Sains, 15 (2), 13-21. FMIPA UNESA.
- Vebriari, P. (2010). Penerapan Multimedia pada pokok Bahasan Substansi Genetika di Kelas XII SMA Yadika Bangil (Skripsi). Surabaya: Unesa.



JPII 5 (1) (2016) 51-55

Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# THE EFFECTIVENESS OF PROJECT-BASED E-LEARNING TO IMPROVE ICT LITERACY

# E. D. S. Eliana<sup>1</sup>, Senam<sup>2</sup>, I. Wilujeng<sup>3</sup>, Jumadi<sup>4</sup>

<sup>1</sup>SMPN 2 Selakau Timur, Kaupaten Sambas, Indonesia <sup>2, 3, 4</sup> Universitas Negeri Yogyakarta, Indonesia

DOI: 10.15294/jpii.v5i1.5789

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

### ABSTRACT

This study aims to reveal the effectiveness of science teaching based on project-based learning to improve ICT literacy learners in the junior high school with the category of high, medium and low. This research uses descriptive method to describe the students' equipness of ICT literacy in the science learning based on the project-based learning that is integrated with e-learning. All of the population in this study are junior high school of curriculum pilot project in 2013 in Singkawang. The sampling in this study uses stratified random sampling to determine three of the four schools that represent the school with a category of high, medium and low based on the National Examination score on 2015, namely, SMPN 1 Singkawang, SMPN 3 Singkawang, and SMPN 7 Singkawang and from each school are randomly selected one class. The data collection is done by the observation and questionnaires of the students' equipness in ICT literacy with effective criteria only if it is in a good or excellent criteria. Based on the analysis, project-based learning science-based learning is effective in equipping ICT literacy learners at junior high school at the categories of high, medium and low.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: e-learning, ICT literacy, Project based learning, Teaching and learning process

# **INTRODUCTION**

The need for information technology becoming increasingly more important today where Indonesia is entering the free market of ASEAN or the ASEAN Economic Community (AEC). All of Indonesian people are expected to have the ability in the field of technology. The learners are expected to have skills in the field of information technology (ICT). Teachers who play a direct role in the education are required to be more creative in giving lessons to students.

The mastery of information technology on the learner or known as ICT literacy is important to the learners. The learners are required to be creative, innovative and responsive in facing the changes in the XXI century as confirmed by Magaña & Frenkel, 2009, "A child entering the

\*Alamat korespondensi:

Email: twinenna@gmail.com

new century will Likely face more risks and uncertainties and will need to gain more knowledge and master more skills than any generation before "this statement shows that in order to face the XXI century learners are required to learn more. Learners face the risks and uncertainties in the XXI century in line with the development environment so rapidly, such as technology, science, economics and socio-culture, so that students are required to learn more and be proactive in order to have the knowledge and skills / expertise were adequate, especially in the field of information technology (ICT). Ivankovića et al. (2013) states that "ICT literacy becomes an important precondition for the socialization and professional career. Therefore, education as an important factor of social development plays a key role in the ICT literacy. This means ICT literacy is very important to have for the learners.

The importance of mastering ICT is because ICT becomes one of an important requirements by learners in the competence of the XXI century, it is the foundational knowledge competency. The competence at XXI century is divided into three, namely foundational knowledge (to know), meta knowledge (to act), and humanistic knowledge (to value) and ICT literacy is one aspect of the foundational knowledge in addition to core content knowledge and cross disciplinary knowledge (Kareluik, 2013).

ICT literacy is referred as one of the skills required for become successful in the XXI century (Wilson, et al., 2015). ICT literacy is defined as the ability to effectively evaluate, navigation, and build the information by using various digital technologies. ETS (2007) mentions "ICT literacy is using digital technology, communications tools, and / or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society" which means ICT literacy is able to use digital technology, communications equipment, and / or networks to access, manage, integrate, evaluate, and create information that is useful for the knowledge society. CETF (2008) defines ICT literacy is the ability to use digital technology and communication tools, and / or networks to access, manage, integrate, evaluate, create and communicate information to be function in the knowledge society.

Badke (2009) stated that ICT literacy is also known as "iSkill". Learners who have the skill of ICT literacy need a learning with ICT. Ezekoka & Gertrude (2015) states "ICT is not designed to replace face-to-face interaction; it is designed to supplement it by allowing people to communicate anytime and anywhere ", which means that ICT is not designed to replace the face to face interaction between teachers and learners, but ICT is designed to support the learning and complements and enables teachers and learners to communicate wherever and whenever. According Krajcik (1994) use technology in project-based science to make the environment more authentic for students, because computers provide access to data and information, expand interaction and collaboration with others through the network, promote research laboratories, and merge tool used to produce the artifact.

The students' knowledge about technology is important, in order to meet the ICT literacy, the learners can do it by via e-learning. E-learning is expected to allow learners to understand the newest knowledge and technology (ICT literacy) and facilitate learners to learn without being limited by the space and time. Based on the survey results on the use of information technology by the junior high school teacher in science class in Indonesia, showed that the use of ICT in teaching process is low (Sumintono, 2012). Therefore, we need a learning model that can facilitate the learners to have the ICT literacy. One of the learning model suggested in the curriculum 2013 is scientific approach, which is one of the XXI century learning model is project-based learning and to facilitate the learning of ICT literacy that can be integrated with e-learning. Blumenfeld et al. (1991) state that the project-based learning is a comprehensive approach to teaching and learning that is designed for students doing a research on real problems. Bagheri & Abdullah (2013) states that "PBL could foreseeably ensure more effective result by allowing the student to actively perticipate in the learning process and allowing the student to produce something in collaborating with other" Project-based learning can provide a more effective and allow learners to participate actively in the learning process and makes it pos-

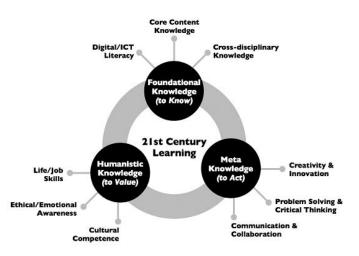


Figure 1. Competency Mapping XXI Century (Kareluik, 2013)

sible to produce something with the cooperation of others.

Project-based learning gives students the opportunity to broaden their knowledge and develop skills through problem solving and investigation. Real problems or questions arising form the core of every project-based learning experience with e-learning, and learners must conduct investigations and obtain the necessary information to arrive at a conclusion. Project-based learning also encourages students to share feedback and insights with colleagues in collaborative groups, and then use e-Learning modern technology to share their findings. ICT can improve learning outcomes in order to support a different sense; support new collaboration with online production, computer and networking tools; supports the differentiation and diversity; and empowers students to personalize their learning process. Therefore, project-based learning using ICT should be introduced in the classroom to support learners to create their own knowledge (Soparat & Klaysom, 2015).

Soparat & Klaysom (2015) stated that ICT as a learning content project-based learning does not only support the development of main competencies of the learners. Nowadays, network, computer and internet access are used more than just search for data, email, or chat, but should be used to support the students education and should be focused on the content of the knowledge and competence.

Based on the several studies above can be stated that the project-based learning that is integrated with e-learning can give students the opportunity to broaden their knowledge and develop skills based on problem-solving and investigation, using e-learning learners can search for and share information more widely and depth, supports the differentiation and diversity, empower learners to personalize the learning process, and provides an opportunity to learners to master information technology (ICT) deeper so that the needs of learners in order to mastery ICT can be fullfiled.

#### **METHOD**

This research uses descriptive explorative method. Exploratory descriptive study aimed to describe the state of a phenomenon, in this study was not intended to test a specific hypothesis but describe variable as it is, symptoms or circumstances (Arikunto, 2002). The phenomenon described in this study is the equipness of learners' ICT literacy in science teaching based on projectbased learning that is integrated with e-learning. The population in the study were all junior high school pilot project curriculum in 2013 in Singkawang. The sampling on this research using stratified random sampling to determine three of the five schools that represent the school with a category of high, medium and low based on the National Examination score on 2015. The three schools as the sampled are SMPN 1 Singkawang, Singkawang SMPN 3, and SMPN 7 Singkawang, Of the three schools have one of each class by cluster random to determine which classes will be given science learning based on e-learning integrated project-based learning.

Data collected by observation and questionnaires of equipness of ICT literacy. Instruments used in this study are the development project-based learning made by Muskania (2015) which has been tested for its validity and reliability. For the observation technique, the instrument used is in the form of observation sheet. Questionnaires used to measure junior high school students of their equipness of ICT literacy.

The equipness of ICT literacy data are obtained through observation. The result scores were categorized based on the assessment by the 5 caparator categories (Anwar, 2002) Project based science learning is effective for improving junior high shool students' skill of ICT literacy only if the equipness of ICT literacy observation results which is converted with a likert scale that are in the category of good or excellent.

#### **RESULTS AND DISCUSSION**

The equipness of ICT literacy in the schools in the category of high, medium and low measured using observation sheets and questionnaires ICT literacy. The results of the equipness of ICT literacy observations in this research is learners' progress data toward ICT literacy by the tasks given to the learners. The equipness of ICT literacy data at the high school category of the observations are presented in Table 1.

According to table 1 the overall average of the ICT literacy equipness aspects is 98.96 when converted to likert scale is at very good criteria. The ICT literacy equipness from the questionnaire results in the high category school learners are shown in table 2. The learners response to the ICT literacy questionnaire of high category school that is at very good criteria. Therefore, it can be said that Project based science learning is effective to equip ICT literacy learners of high junior category. Table 3 shows the equip observation percentage of ICT literacy and the ICT literacy equipness average of learners from médium school category is at very good criteria. Based the average on table 4, if it is converted to likert scale, the response of the ICT literacy average at low category school is in very good criteria. Based on table 5 the overall average of ICT literacy equipness aspects of 98.21% is at very good criteria. The ICT literacy equipness of the questionnaire results in a low category school learners are shown in table 6. The questionnaires average results of ICT literacy equipness is 84.24 if converted with the likert scale responses is included in very good criteria.

Table 1. The Percentage of the ICT Literacy
Equipness, the Learners' Average in Each Stu-
dent Aspect in the High Category School

ICT LiteracyAspect	Observation Percentage (%)
Access	93,75
Managing	100,00
Integrating	100,00
Evaluating	100,00
Making	100,00
Communicating	100,00
Average	98,96

**Table 2.** Questionnaire Assessment about theICT Litercy Equipness in the High CategorySchool Students

Criteria	ICT LiteracyScore
Min	74,29
Max	99,05
Average	88,33
Deviation Standard	5,17

**Table 3.** The Percentage of the ICT LiteracyEquipness, the Learners' Average in Each Student Aspect in the Medium Category School

ICT LiteracyAspect	Observation Percentage (%)
Access	89,24
Managing	100,00
Integrating	100,00
Evaluating	100,00
Making	100,00
Communicating	100,00
Average	98,21

The analysis results of the ICT literacy equipness are consequence to investigators alleged. The results of this study are consistent with Muskania research (2015), the statement is a project based science learning device can equip ICT literacy learners. Project based learning provides an opportunity for learners to broaden the knowledge base and develop skills through problem solving and investigation. Real problems or the questions that arise are the core of Project based learning. By using project based learning, we can encourage the learners to share and get feedback and insights and with e-learning integration, the learners can obtain more information and can share their findings widely.

**Tabel 4.** Questionnaire Assessment about theICT Litercy Equipness in the Low CategorySchool Students

Criteria	ICT LiteracyScore
Min	60,00
Max	94,29
Rata-rata	84,24
Deviation Standard	7,03

**Tabel 5.** The Percentage of the ICT Literacy Equipness, the Learners' Average in Each Student Aspect in the Low Category School

ICT Literacy Aspect	Observation Percent- age (%)	
Access	89,24	
Managing	100,00	
Integrating	100,00	
Evaluating	100,00	
Making	100,00	
Communicating	100,00	
Average	98,21	

**Tabel 6.** Questionnaire Assessment about theICT Litercy Equipness in the Low CategorySchool Students

Criteria	ICT LiteracyScore
Min	60,00
Max	94,29
Average	84,24
Deviation Standard	7,03

Online learning can provide opportunities for the learners to read the material deeper, exercises and assignments, as well as interact directly with teachers via chat gives further motivation and generate more effectively than traditional classroom. Kubiatko & Vaculova (2011) explains that in this era, project based learning will be connected with ICT. ICT will provide a deeper

#### CONCLUSION

Based on the results and discussion of this study concluded that Project based science learning is effective to equip the learners ICT literacy of junior school categories of high, medium, and low with the observations and questionnaires are in very good criteria. Project based science learning integrated with e-learning can be applied as early as possible to equip ICT literacy because it is one of the XXI century competencies that must be owned by the current learner and as a provision for future the which is full of global competition.

#### REFERENCES

- Arikunto.(2002). Metodologi Penelitian Suatu Pendekatan Proposal. Jakarta: PT. Rineka Cipta
- Azwar, S. (2002). *Tes Prestasi.* Yogyakarta: Pustaka Belajar.
- Badke, W. (2009). Media, ICT, and information literacy. *Trade Journals*, *33*(1), 47-49.
- Bagheri, M., Ali, & M., Abdullah, M. C. (2013). Effect of Project Based Learning Strategy on Self Directed Learning Skill of Educational Technology Student. *Contemporary Educational Technol*ogy, 5(1), 15-29.
- Blumenfeld, P. C., Soloway, E. & Marx, R. W. (1991). Motivating Project-Based Learning Sustaining The Doing Supporting The Learning. Michigan: Lawrence Erbauw Associated, Inc.
- CETF. (2008). California ICT Digital Literacy Assessments and Curriculum Framework. California: CETF.
- ETS. (2007). *Digital Transformation A Framework for ICT Literacy.* United State of America: Educational Testing Service.
- Ezekoka & K, Getrude. (2015). Maximizing the effects of collaborative learning through ICT. *Procedia* -

Social and Behavioral Sciences, 176(1), 1005-1011.

- Francese, R., Gravino, C., Risi, M., & Scanniello, G. (2015). Using Project-Based-Learning in a mobile application development course An experience report. *Journal of Visual Languages and Computing*, 31(1), 196–205.
- Ivankovića, A. Š. (2013). ICT literacy among the students of the Faculty of Philosophy, University of Mostar. *Procedia - Social and Behavioral Sciences*, 93(1), 684-688.
- Kareluik. (2013). What Knowledge Is of Most Worth:Teacher Knowledge for 21st Century Learning. Journal of Digital Learning in Teacher Education, 3(1), 127-140.
- Krajcik, J. S. (1994). A Collaborative Model for Helping Middle Grade Science Teachers Learn Projec-based Instruction . *The University of Chicago Press*, 4(1), 483-497.
- Kubiatko, M., & Vaculova, I. (2011). Desaigning a Project Management e-course by Using Project Based Learning: Characteristic and The Experiences with Application in The Science Subjects. Energy Education Science and Technology Part B: Social and Educational Studies, 5(1), 65-74.
- Magaña, S., & Frenkel, P. (2009). Transforming Teaching and Learning for the 21st Century. Promethean, 1(1), 32-41.
- Muskania, R. (2015). Pengembangan Perangkat Pembelajaran IPA berbasis Project Based Learning untuk Membekali Foundational Knowledge dan Meningkatkan Scientific Literacy Peserta didik SMP. Yogyakarta: Universitas Negeri Yogyakarta.
- Soparat, A. Arnold & Klaysom. (2015). The Development of Thai Learners' Key Competencies by Project-based Learning Using ICT. International Journal of Research in Education and Science, 3(1), 12-22.
- Sumintono, B. W. (2012). Penggunaan Teknologi Informasi dan Komunikasi dalam Pengajaran Guru Guru Sains SMP di Indonesia. Jurnal Pengajaran MIPA, 17(1), 23-31.
- Wilson, M., Scaliseb, K., & Gochyyev, P. (2015). Rethinking ICT literacy: From computer skills to socialnetwork settings. *Thinking Skills and Creativity*, 18(1), 65-80.

JPII 5 (1) (2016) 56-62



Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# STUDENT MISCONCEPTION ON REDOX TITRATION (A CHALLENGE ON THE COURSE IMPLEMENTATION THROUGH COGNITIVE DISSONANCE BASED ON THE MULTIPLE REPRESENTATIONS)

# H. R. Widarti<sup>1</sup>, A. Permanasari<sup>2</sup>, S. Mulyani<sup>3</sup>

<sup>1</sup>Universitas Negeri Malang, Indonesia <sup>2,3</sup>Universitas Pendidikan Indonesia, Bandung, Indonesia

DOI: 10.15294/jpii.v5i1.5790

Accepted: 23 January 2016. Approved: 28 March 2016. Published: April 2016

#### ABSTRACT

The misconception is one of the obstacles in the concept mastery that needed to be minimalized. This descriptive study was conducted to find the patterns of misconceptions which have occurred on college students who participating in the redox titration course subject. Efforts to minimize misconceptions have been conducted through lectures using the multiple representations with the cognitive dissonance strategies on the 30 students who joined the Fundamentals of Analytical Chemistry course. The research instrument used in this study was 6 multiple-choice tests with reasons. In order to detect the misconception, Certainty of Response Index technique was performed. The preliminary study results showed that 34.30% of students experiencing the misconceptions on redox titration. After treatments, the misconceptions reduced to 28.17%. A misconception that cannot be eliminated was related to the concepts involving in the microscopic and symbolic appearances.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: e-learning, ICT literacy, Project based learning, Teaching and learning process

### **INTRODUCTION**

Redox Titration is one of the conventional methods of quantitative chemical analysis. The study material on redox titration is closely related to the concept of the redox titration that has been studied by students in high school level. In the higher education level, the concept of redox and titration are studied in the course of Basic Chemistry. The redox titration is deeply studied by students in the course of Fundamentals of Analytical Chemistry. The study material on redox titration discusses about the concepts, types, and application of redox titration. Although the students have learned the concept of redox, there are many students who do not properly understand the study materials related to the redox titration. Some students are even experiencing the misconceptions.

\*Alamat korespondensi: Email: hayuniretno64@gmail.com

Misconceptions that occur in students is one significant factor that plays a role in inhibiting the understanding of the concept. The misconception is the inconsistency of the understanding between the views of students and scientists (Louga et al., 2013). In line with Berg (1991), the misconceptions occur when students are not in accordance with the experts' conception. Likewise that proposed by Driver et al. in Pinarbasi et al. (2009), it said that the misconception was an inconsistency or incompatibility of the students' conceptions with the scientific conception. Most of the students have had its own ideas about chemical concepts that have been acquired in high school before they enter higher education in college. This circumstance sets the students opinion to often relate less precise relationship between their newly acquired knowledge with their prior knowledge. Therefore, it raises the new understanding that is not in accordance with the expectations of experts. The students' everyday experience, their creativity, their perception, and some textbooks can lead to the misconceptions. According to Louga et al. (2013) the students who have a good understanding of concepts could build a meaningful understanding in the colligative properties. Eymur et al. (2013) reported that the teacher-candidate students had the same misconceptions with students. The misconceptions itself was difficult to be removed through learning. A teacher needs to implement appropriate learning strategies to identify and to reduce the misconceptions. The misconceptions that allowed passing through would be fatal and would be very harmful because it can affect learning outcomes.

Several researches on the chemistry misconceptions in chemistry have been identified by experts. Pinarbasi (2007) reported that students had a number of common misconceptions on the topic of acids and bases. Almost all the students managed to equalize the equation, but they could not draw the molecular diagrams to explain the equations in submicroscopic correctly. Moreover, the students' experience in the previous study influenced the material conception of the reaction equilibrium. Al-Balushi et al. (2012) reported that 12 grade students had difficulty in answering the questions related to visual representation. Redox material misconception had been experienced by students, for example: they had a difficulty on distinguishing the definition of the oxygen and electrons transfer, they often experience an error in the determination of the oxidation number of the element or compound, they did not knowing the key concept of oxidation and its relation to the concept of charge; and also they had a difficulty on how to apply the equalization to equalize the redox reactions. Misconceptions are commonly found in chemistry materials of study prior to inadequate teaching media. Misconceptions on redox titration will affect the students in the understanding and application of redox titration. Their misconceptions on redox titration may also disrupt the formation of a scientific conception of students in other study materials. Therefore, misconceptions on redox titration material in the

course of Fundamentals of Analytical Chemistry must be addressed immediately.

In order to identify the occurrence of misconceptions, a certainty of response index (CRI) scale technique was conducted, which has been modified from Hasan et al. (1999). CRI is a degree of certainty of the students to answer the questions. In this research, there were two instruments used, i.e. multiple-choice test and the level of confidence (CRI). The use CRI technique was able to distinguish the differences among a well-known concepts, unknown concepts and misconceptions. CRI scale used in the study was modified from Hasan et al. (1999). The four scale (1-4) with details 1 = guessing, 2 = less confident, 3 = confident, and 4 = very confident. Low CRI value (1-2) showed the lack of confidence of students to answer questions. High CRI value (3-4) showed high confidence of students to answer questions. Uncertainty of students to answer the questions was caused by the lack of confidence in students. Kurbanoglu & Akin (2010) stated that students who master the concept properly will have a high confidence. The students who answered the question with a lower CRI value (1-2) shows that these students do not understand the concept. High CRI value (3-4) showed that students have the confidence in answering questions. It indicates that the student can master the concept of theory. Criteria for low and high CRI answers are shown in table 1.

There was a modification on CRI value criteria set by Hasan et al. (1999), since it could emerge the alternative answers by students; even it is only few answers. The reason is because of Indonesian students tends to be less confident in giving the reasons on the given answers. By this reason, a possible answer by those kinds of students is a correct answer with a correct reason but with a low level of confidence. It means that the students understood the concepts well, but lack of confidence (Hakim et al., 2012).

The preliminary study on the titration by 38 students who joined the Fundamentals of Analytical Chemistry course had found the difficulty in understanding subject materials, especi-

Answers criteria Low CRI (1-2) High CRI (3-4) Correct answer Correct answer with wrong reasons and Correct answer with correct reasons low CRI is showing that they do not and high CRI is showing a concept understand the concept (*lucky guessing*) mastery Wrong answer with wrong reasons and Wrong answer with wrong reasons Wrong answer low CRI is showing the low underand high CRI is showing that there is standing on concept a misconception.

Table 1. Criteria of misconceptions identification based on the CRI results (Hasan, 1999)

ally on the quantitative analysis of the material. Generally, based on the research on the students' answers, they were weak in mathematics literacy, and also weak in the ability to provide a relevant analysis of how to determine the choice of indicators in a titration (Widarti et al., 2014). It was highly associated with a lower ability of students in explaining the phenomenon through microscopic and symbolic approaches. Therefore, the descriptive study was conducted to determine the student misconceptions in redox titration study materials.

#### METHOD

The method used in this study was a descriptive method with a form of case study research. Thirty subjects of Chemistry Education students in the third semester year 2014-2015 in State University of Malang were studied. They joined the Fundamentals of Analytical Chemistry course subject. The research instrument employed was a multiple-choice test with open answers in the end of each question to measure their redox titration concepts mastery. Six problems were given in the test. The reason given by students was a reflection of their thinking ability and their understanding on the concepts learned.

#### **RESULTS AND DISCUSSION**

The results of preliminary study on the redox titration subject material found that there were 34.30% misconceptions. Some methods to overcome such misconceptions were to adjust the syllabus to the students thinking way, cognitive conflict, analogy, partner interaction, metacognition, and demonstrations. According to the Berg (1991) who stated that misconceptions could be addressed using an innovative model of lectures; for example, by using a variety of representations. Hand & Chio (2010) reported that multiple representations could give the positive impact on students' ability to construct the arguments in lab classes. Similarly, McDermott & Hand (2013) stated that the use of multiple representations to support the task of writing-to-learn could act as a pedagogical tool in enhancing the chemistry learning in schools. Domin & Bodner (2012) also reported that the use of multiple representations helped students in solving the problems in chemical concepts. Research on cognitive dissonance in chemistry through multiple representations have been made by Linenberger et al. (2012), who reported that the combination of representations to encourage students to try to

make the relationship between representation. In this study, the model of multiple representations associated with cognitive dissonance strategy has been implemented in the redox titration lecture materials. It was hoped that using this method, there was a change in the concept understanding.

Each student has a different understanding capacity and perception on the studied concept. These differences lead the students to have different levels of ability and misconceptions about the concept. In order to determine the student misconceptions in the redox titration material of study, a multiple-choice test was conducted with open answers and CRI. The distribution of the problem on the redox titration are shown in Table 2.

The percentage of students answer questions on redox titration of each item are shown in Table 3.

Problem number 1 was related to calculate the concentration of the redox titration which resulted in 66% of students had the misconceptions. Most of students used a dilution formula, which should not be needed in the titration. Besides, the students also did not write down the equation for the case, wrong in calculating the amount of the number of moles of KMnO4. This was possible to happen since the students were not familiar with the concept of redox reactions. Examples of student answer can be seen in Figure 1.

Jawaban = C. 0,0626 M.	
Alason dibet , UKMINO4 + 10 mL	
M Nhala Og , CHOSOD M	
U. Ma, C204, 12,50 ML, 12,56 M	L, Ran 12,47 mL - 12,56 + 12,56 + 12,47 . 12,5
ditonya: MKMnOy ,?	3
Penyelesaian	
Mi Vi , Ma Va	
0.05 - 12.51 - Ms. 10	
0.6253 . M. 10	
M2 , 0/6255	
tD	
- 0.06255 atom	0.8626 M North Carlos

Figure 1. The example of student answer on problem no 1

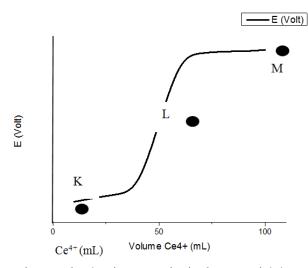
Problem number 2, 3 and 4 were related to interpreting the species and calculating the potential value (E) on the redox titration. Some students still had the misconceptions as much as 23%, 20%, and 14%, respectively. In question number 2, students answered that at the point K (10 ml Ce<sup>4+</sup>), the dominant species were Fe<sup>2+</sup> dan Ce<sup>4+</sup> as Fe<sup>2+</sup>was previously appeared. The students believed that there was no Fe<sup>3+</sup>formed in the solution. This problem was happened also in the problem number 3 where the students answered that at M point (addition of 80 ml Ce<sup>4+</sup>) there were only Fe<sup>2+</sup> and Fe<sup>3+</sup>. M point was the

**Table 2.** The distribution of redox titration problems

No		Problems		
Calculating the Concentration on Redox Titration				
1	ic conditions in triplo.		$1500 \text{ M Na}_2\text{C}_2\text{O}_4$ solution under acid- needed are 12,50 mL; 12,56 mL; and $12,50 \text{ mL}$ ; $12,56 \text{ mL}$ ; and $12,50 \text{ mL}$ ; $12,56 \text{ mL}$ ; $12$	
	a. 0.3128 M	c. 0.0626 M	7	
	b. 0.1250 M	d. 0.0250 M		
	Reason/Explanation:		CRI:	

Interpreting the existing species and potential value (E) on the redox titration

Problems no 2-4 Redox titration graph 50 mL 0.100 M Fe<sup>2+</sup> ( $E^{\circ}Fe^{3+}/Fe^{2+} = 0.767$  V)with a solution of 0.100 M Ce<sup>4+</sup> ( $E^{\circ}Ce^{4+}/Ce^{3+} = 1.70$  V) is as follows:



- Based on the curve, what are the dominant species in the potential determination of solution in K point (10 mL addition of Ce<sup>4+</sup>) and how much is the E value?
  a. Fe<sup>2+</sup>, Ce<sup>4+</sup> and E = 0.73 V
  b. Fe<sup>2+</sup>, Fe<sup>3+</sup> and E = 0.73 V
  c. Fe<sup>3+</sup>, Ce<sup>3+</sup> and E = 0.78 V
  d. Fe<sup>3+</sup>, Ce<sup>3+</sup> and E = 0.78 V
  - d.  $Fe^{2+}$ ,  $Fe^{3+}$  and E = 0.78 V Reason/Explanation:

CRI:

- Based on the curve, what are the dominant species in the potential determination of solution in M point (80 mL addition of Ce<sup>4+</sup>), and how much is the E value?
  a. Ce<sup>3+</sup>, Ce<sup>4+</sup> and E = 1.67 V
  b. Fe<sup>2+</sup>, Fe<sup>3+</sup> and E = 1.67 V
  c. Ce<sup>3+</sup>, Ce<sup>4+</sup> and E = 1.69 V
  d. Fe<sup>2+</sup>, Fe<sup>3+</sup> and E = 1.69 V
  Reason/Explanation: CRI:
- Based on the curve, what are the dominant species in the potential determination of solution in L point (50 mL addition of Ce<sup>4+</sup>) and how much is the E value?
  a. Fe<sup>2+</sup>, Fe<sup>3+</sup>, Ce<sup>3+</sup>, Ce<sup>4+</sup>and E = 1.23 V
  b. Fe<sup>2+</sup>, Fe<sup>3+</sup>, Ce<sup>3+</sup>, Ce<sup>4+</sup>and E = 1.23 V
  c. Fe<sup>2+</sup>, Fe<sup>3+</sup>, Ce<sup>3+</sup>, Ce<sup>4+</sup>and E = 1.32 V
  d. Fe<sup>2+</sup>, Fe<sup>3+</sup>, Ce<sup>3+</sup> and E = 1.32 V
  Reason/Explanation: CRI:

Table 2. Continue

Identify the characteristics of the substances involved in redox titration

5 Which statement is true in a redox titration....
a. Titration of permanganomeri requires the addition of an indicator to determine the titration endpoint
b. Ce<sup>4+</sup>ions are directly undergo on hydrolysis in a low-pH solutions
c. I, is absorbed on the surface of α-amylose to produce blue color

CRI:

CRI:

d. Iodide ion acts as a reductant in the iodometric titration

Reason/Explanation:

Choosing the right type of redox titration to analyze samples

6	Given so	ome reduction potentials as follow	/S:
	Ce4+ +	$e \Leftrightarrow Ce^{3+}$	E° = 1.61 V
	MnO <sub>4</sub>	$+8H^+ + 5e \Leftrightarrow Mn^{2+} + 4H_2O$	E° = 1.51 V
	$Cr_{2}O_{7}^{\frac{1}{2}}$	$+ 14H^+ + 6e \implies 2Cr^{3+} + 7H_2O$	E° = 1.33 V
	Fe <sup>3+</sup> +	$e \Leftrightarrow Fe^{2+}$	E° = 0.771 V
	$I_2(aq) +$	$2e \iff 2I^{-}$	E° = 0.6197 V
		the most suitable titration by usin	ig Fe?
	a.	Permanganometry and iodomet	ry
	b.	Cerimetry dan iodometry	
	с.	Chromatometry dan permangan	nometry
	d.	Permanganometry dan cerimetr	v
	Reason	Explanation:	<u>,</u>

<b>Table 3.</b> Distribution of student misconceptions on redox titration ( $n = 3$	Table 3	. Distribution	of studen	t misconceptions	on redox titration	(n = 30)
---	---------	----------------	-----------	------------------	--------------------	----------

Problems no	Misconceptions	Percentage of students
1	Did not write down the equation and applied a dilution formula	66
2	Mentioned in the K point (addition of 10 mL $Ce^{4+}$ ), the dominant species were $Fe^{2+}$ and $Ce^{4+}$ since $Fe^{2+}$ was previously mentioned	23
3	Mentioned in the M point (80 mL Ce <sup>4+</sup> ) there were only Fe <sup>2+</sup> dan Fe <sup>3+</sup> species	20
4	Mentioned in the L point (50 mL Ce <sup>4+</sup> ) there were only $Fe^{2+}$ , $Fe^{3+}$ , and $Ce^{2+}$ species, $Ce^{4+}$ had completely reacted.	14
5	Permanganometryrequired indicators	26
6	Did not count the number of E cells for the ongoing redox reactions	20
	Average	28.17

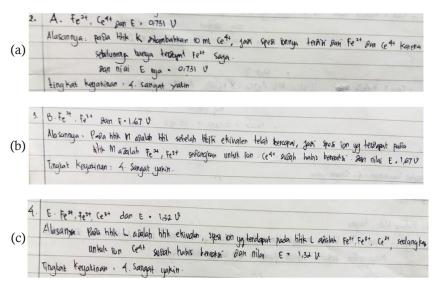


Figure 2. The example of student answers on the problems no 2 (a), no 3 (b), and no 4 (c)

curve region over the equivalent point, the dominant species that involved in determining the potential value were Ce2+ dan Ce4+. The similar thing happened in the problem number 4 where students confidently answered that at the L point, (50 ml Ce<sup>4+</sup>) there were only Fe<sup>2+</sup>, Fe<sup>3+</sup>, and Ce<sup>2+</sup>, and Ce4+had completely reacted. In fact, at the equivalent point, the amount of Fe<sup>2+</sup> was the same with Ce<sup>4+</sup>. Both of them had the identical potentioal; therefore, the dominant species in the solution were  $Fe^{2+}$ ,  $Fe^{3+}$ ,  $Ce^{2+}$  and  $Ce^{3+}$ . All the answers impacted on the calculation of the solution, where students did not calculate the potential based on the reaction that occurs in solution but only suspect of the curve. Sample of answers are shown in Figure 2.

Problem number 5 was associated with the identifying characteristics of the substance involved in redox titration. There were 26% of students still had the misconceptions on this concept. There were some students who confidently answered that in the permanganometry,  $K_2Cr_2O_7$ was required as an indicator. In fact, in permanganometry, it is unnecessary to use an indicator since KMNO<sub>4</sub> is already involved as an indicator (autoindicator). The example of student' answer related to the characteristics in redox titration is shown in Figure 3.

Problem number 6 was related to choose the right type of redox titration to analyze a sample. There were 20% of the students still had misconceptions in this concept. There was student who confidently answered without counting the E cell reaction that occurred. Students assumed that the most redox titration were permanganometry and iodometric. In fact, in redox titration, the occurrence of a reaction is conducted when the value of its cell potential is positive. The example of student' answers on question no 6 is shown in Figure 4.

From the tables and figures above, it shows that although a treatment was conducted on learning, it turned out that misconceptions could not diminished altogether. This phenomenon was in line with the statement of the educational experts that misconception is very difficult to change through common learning. Based on the observations, the concept of an abstract nature, which requires a clear picture to understand, was the most difficult concept which has a big chance of a misconception. The results showed that the biggest case of misconceptions was related to the microscopic appearance of the ions in the process of titration, and also its symbolic equations during reactions. In the redox titration, the biggest misconception occurred in determining the concentration, and what are the dominant species that exist in the solution before the equivalent point, and also the characteristics of redox titration.

#### CONCLUSION

The research results showed that misconceptions were still found on the particular redox titration lecture materials. The misconceptions were happened to concepts which involving calculations on concentration, equation, and species that exist in the solution in the titration process, and also the redox titration characteristics involving potential calculation. The preliminary studies showed 34.30% of students had the misconceptions on redox titration. Treatments that had been made to minimize these misconceptions could suppress it to the level of 28.17%. In the redox titration, the misconceptions that could not be eliminated were related to the concepts involving microscopic and symbolic appearances.

Based on the research findings, the developed learning strategy was quite appropriate to reduce the misconceptions but was unable to make "a zero misconception". This was understandable because of misconceptions could retain longer in the students and it was difficult to change. The follow-up activities were needed to allow the logical thinking of students in order to change their misconceptions into the facts. One strategy to anticipate the more complicated misconceptions was the discussion with students on

Carena pada htrasi permanganometri Dibutuhkan Indikator KaCro 07 yang nanhi
akan bereaksi dengan ion Agt membentuk endapan merah. Inilah dutandaka
 untuk proses hitrani hanus regera dihentikan . (talik akhir hitrasi klah tercapai)

Figure 3.Example of student' answer on the problem number 5

6	A. Per manganometri sal	iozometri	
		tiltrasi resolts kebanyatan segunatar permangunomet	th' an Roometh' karena
	Prinsip untuk	terra metore terretruit menggunden bruten KMnOz	Dereda 10
		ant your	

Figure 4. The example of student' answer on question no 6

the topic before starting the lectures to know what misconceptions brought by the students. Subsequently, the remedial test and deep interview could be conducted to decrease the chance of complicated misconceptions.

#### REFERENCES

- Al-Balushi, M., Ambusaidi, K.cA., and Al-Shuaili, H. A., Taylor, N. (2012). Omani twelfth grade students' most common misconceptions in chemistry. *Science Education International*, 23(1), 221-240.
- Berg, E. (1991). *Miskonsepsi Fisika dan Remediasinya*. Salatiga: Universitas Kristen Satya Wacana.
- Domin, D. & Bodner, G. (2012). Using students' representationsconstructed during problem solving to infer conceptual understanding. *Journal Chemical Education.* 89(1), 837-843.
- Eymur, G., Cetin, P. & Geban O. (2013). Analysis of the alternative conceptions of preservice teachers and high school students concerning atomic size.*90*(1), 976-980.
- Hakim, A., Liliasari.,& Kadarohman, A. (2012). Student understanding of Natural Product Concept of Primary and Secondary Metabolites Using CRI Modified.*International Online Jour*nal of Educational Sciences.4(3), 544-553
- Hand, B. & Chio, A. (2010). Examining the impact of student use of multiple modal representations in constructing arguments in organic chemistry laboratory classes. *Res Sci Educ.* 40(29), 29-44.
- Hasan, S., Bagayoko, D., & Kelley, E. L. (1999). Misconceptions and The Certanty of Response Index (CRI). *Physics Education.34*(5), 294-299.

- Kurbanoglu, N. I., & Akin, A. (2010). The Relationships between University Students' Chemistry Laboratory Anxiety, Attitudes and Self-Effiency Beliefs. *Aistralian Journal of Teacher Education.35*(18), 48-59.
- Linenberger, J. K. and Bretz, L. S. (2012).Generating cognitive dissonance in student interviews through multiple representations.*Chemical Education Research & Pracice.13*(1), 172-178.
- Luoga, N. E., Ndunguru, A. P., & Mkoma, L. S. (2013). High school students' misconceptions about colligative properties in chemistry. *Tanzania Journal of Natural & Applied Sciences.* 4(1), 575-581.
- McDermott, A. M. & Hand, B. (2013). The impact of embedding multiple modes of representationwithin writing tasks on high school students' chemistry understanding. *Instructional Science.41*(1), 217-246.
- Nakhleh, M.B. & Krajcik, J.S. (1994). Influence of levels of information as presented bydifferent Technologies on students. understanding of acid, base, and pH concepts. *Journal of Researchin Science Teaching.34*(1), 1077–1096.
- Pinarbasi, T. (2007). Turkish undergraduate students misconceptions on acids and bases. *Journal of Baltic Science Education.16*(1), 23-34.
- Pinarbasi, T., Sozbilir, M., & Canpolat, N.(2009). Prospective chemistry teachers' misconceptions about colligative properties: Boiling point elevationand freezing point depression. *Chemistry Education Research and Practice*. 10(1), 273-280.
- Widarti, R.H., Permanasari, A., & Mulyani S. (2014). Analisis Kesulitan Mahasiswa Pada Perkuliahan Dasar-Dasar Kimia Analitik di Universitas Negeri Malang. Malang: Seminar SNKP



JPII 5 (1) (2016) 63-68

Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# IONIC LIQUIDS MATERIAL AS MODERN CONTEXT OF CHEMISTRY IN SCHOOL

# Hernani<sup>1</sup>, A. Mudzakir<sup>2</sup>, O. Sumarna<sup>3</sup>

<sup>1,2,3</sup>Departemen Pendidikan Kimia FPMIPA UPI Bandung, Indonesia

#### DOI: 10.15294/jpii.v5i1.5791

Accepted: 18 January 2016. Approved: 28 March 2016. Published: April 2016

#### ABSTRACT

One way to improve students' chemistry literacy which is demanded in the modernization of modern technologybased chemistry learning is by studying ionic liquids. Low level of scientific literacy of students in Indonesia as revealed in the PISA in 2012 was the main reason of the research. Ionic liquids-based technology are necessary to be applied as a context for learning chemistry because: (1) the attention of the scientific an technology community in the use of ionic liquids as a new generation of green solvent, electrolyte material and fluidic engineering in recent years becomes larger, in line with the strong demands of the industry for the provision of new materials that are reliable, safe, and friendly for various purposes; (2) scientific explanations related to the context of the ionic liquid contains a lot of facts, concepts, principles, laws, models and theories can be used to reinforce the learning content as a media to develop thinking skill (process/competence) as demanded by PISA; (3) The modern technology-based ionic liquid can also be used as a discourse to strengthen scientific attitude. The process of synthesis of ionic liquid involves fairly simple organic reagents, so it deserves to be included in the chemistry subject in school.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: chemistry literacy, chemistry content, ionic liquids material

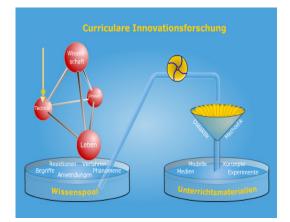
#### INTRODUCTION

One result of the Programme of International Student Asesment studies (PISA) in 2012 about the ability of science literacy, showed that only a few (6.9%) of Indonesian students can clearly identify scientific issues in various contexts (OECD, 2013). According to the Firman (2007), Hayat & Yusuf (2010) it is suspected because of the content of curriculum (experiments and teaching materials), learning, and assessment still focus on the dimensions of the content (knowledge of science) that are mostly done by memorizing whilst ignoring the other dimension of content (knowledge about science), process/competence (thinking skill) and the context of the application of science (e.g. technology).

The integration between contexts of the science application with modern technology is

\*Alamat korespondensi: Email: hernani.kimia@gmail.com the core idea of modern curriculum, as stated by Tausch & Bohrmann-Linde (2007) that the modern curriculum should be able to combine the established content and methods with something innovative. Modernization of curriculum content (especially chemistry) can be done based on the scheme in Figure 1.

Figure 1 shows that the chemistry learning content (Unterrichtsmaterialien) containing the model, media, concepts, and experiments are obtained from scientific sources (Wissenpool) in the form of chain reaction, techniques, definitions, phenomena and implementation. The sources of knowledge can be obtained from daily life in science, technology, environment and culture. Source of chemical science is the scientific explanation of the scientific community/chemist, while Unterrichtsmaterialien are teaching materials that can be taught (teachable), useful (fruitful) and makes it easy to learn (accessible). Sources of knowledge can be collected and filtered based on certain didactic and method into the learning contents.



**Figure 1.** Schematic of Modernization Curriculum Content (Tausch and Bohrmann-Linde, 2007)

The idea of Tausch & Bohrmann-Linde (2007) is in accordance with the views of F. A. Kekule (German chemist) which states that research in Chemistry should relate to the process of metamorphosis of chemistry material in school. This shows that research in Chemical Education should relate to the process of metamorphosis in chemistry curriculum content. The basic knowledge of paradigm-based modern science; e.g. quantum physics, astronomy, molecular biology, and material chemistry; can be introduced to senior high school students in second and third years. Instruments of practicum for high school students should be replaced with ones which support the modern sciences, such as UV (ultraviolet) and VIS. It would also be much better when the high school students in Indonesia have been given the basic knowledge of IR (Infra Red) spectroscopy, NMR (Nuclear Magnetic Resonance) and MS (Mass Spectroscopy), as what happens to students in developed countries.

One of the chemical subjects which support the growth of modern technology is the ionic liquid. This modern material is an object that consists of only the ionic species (cation and anion) without neutral molecules. It maintains a relatively low melting point at the temperatures of <100-150 ° C, generally at room temperature (Hagiwara, et al., 2000). Molten salt which usually has a high melting point and viscosity is also very corrosive. This is in contrast to the ionic liquids which stay in liquid form at room temperature while having a relatively lower viscosity. Moreover, ionic liquids do not have corrosive properties (Toma, et al., 2000). Ionic liquids have

a very wide liquidity range, non-volatile, nonflammable, and high stabilities of heat, chemical and electrochemical (in some cases it even shows thermal stability up to 400  $^{\circ}$  C). In addition, we can overlook the vapor pressure while having the ability to dissolve many organic and inorganic compounds as well as the various miscibility natures when it is mixed with water solvent organic solvents (Davis, et al., 2003).

Ionic liquid-based modern technology are predicted to be able to be used as a context for learning chemistry in school for the following reasons: First, the attention of the scientific community and international technology in the use of ionic liquids as a new generation of green solvent, electrolyte material and fluidic technique in recent years keeps growing, in line with the strong demands of the industry for the provision of new materials that are reliable, safe, and friendly for various purposes (Earle, et al., 2000; Ohno, 2001 & Brennecke et al., 2001). Researches of ionic liquids in electrochemistry are directed as electrolyte materials in batteries, metal plating and sensor system (Bhatt, 2003 & Buzzeo, et al., 2004). Ionic liquids are also developed as green solvent in chemical synthesis, catalyst and biocatalyst (Olivier, et al., 2002; Vidis, et al., 2005 & Miao, et al., 2006). Field engineering uses ionic liquids as fluidic technique as the heat carrier, lubricants, surfactants and the liquid crystals (Ye, et al., 2001; Merrigan, et al., 2000; Awad, et al., 2004; Hollbrey, 1999 & Gordon, et al., 1998). Second, the scientific explanation related to the context of the ionic liquids contains a lot of facts, concepts, principles, laws, models and theories which can be used to reinforce the chemistry learning content as a media to develop thinking skill (process/competence) demanded by PISA. Third, modern technology based on ionic liquids can also be used as a discourse to empower students' science attitude.

#### DISCUSSION

## Modernization of Curriculum Content via Context of Modern Technology of Ionic Liquids-Based

Chemistry education research in this framework is related to the effort to develop experimental design, concept-context and teaching materials that can interpret and communicate the modern science, which makes it easy to understand and attracts students. One of potential material to be used as the chemistry context in the school is ionic liquids in various segments of modern technology shown in Figure 2.

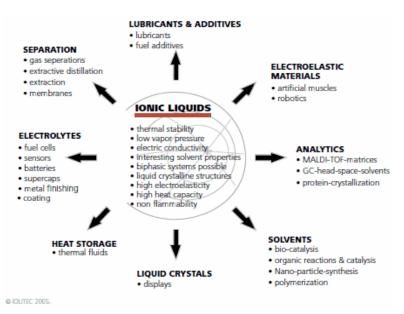


Figure 2. Context of Ionic Liquids Application in Modern Technologies (IOLITEC, 2005)

The ionic liquids are materials that solely consist of ionic species (cation and anion). Cation system in the ionic liquids (and ionic liquid crystal) is generally a bulky organic cation, such as N-alkilammonium, P-alkilposfonium, N-alkyl-pyridinium, S-alkylsulfonium, N-alkilpirolidinium, N, N-dialkilpirazolium and N, Ndialkilimidazolium. The biggest fraction of the research focus has been geared to the cation N, N-dialkilimidazolium 1, because of the enormous differences in physicochemical properties that can be provided. The cation structure is shown in Figure 3.

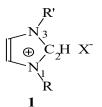


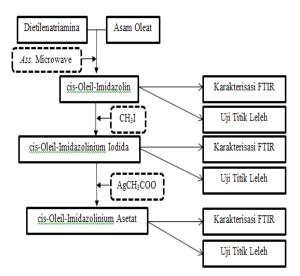
Figure 3. Structure of Cation N,N-dialkilimidazolium 1

The nature of ionic liquids such as thermal properties, electrochemical stability, ionic conductivity and viscosity can be set and adjusted by altering the structure of its cation and anion. These properties cause ionic liquids well-known as tailored-made solvents (Gordon, 1998). The melting point of salt ionic liquid 1-alkyl-3-methyl-imidazolium (with R = CH 3), for example will decline with the increasing length of the alkyl group r`. Having achieved the minimum price (usually in hexyl, heptyl, or octyl groups), the

melting point will increase in line with increasing length of the R group (Gordon, 1998).

# Synthesis and the Characterization of Imidazolinium-Based Ionic Liquids

In summary, the workflow of the research is shown in Figure 4.



**Figure 4.** The process of synthesis and characterization of ionic liquids Cis-Oleyl-midazolinium-Acetate

#### a. Synthesis of Cis-Oleil-Imidazolinium-Asetat

Synthesis of ionic liquids-cis-oleylimidazolinium-acetate is conducted by synthesizing cis-imidazoline, methylation-kuartenerisasi, followed by the replacement of anion. Synthesis of cis-oleyl-imidazoline is performed by a method with microwave assistance. To synthesize cisoleyl-imidazolinium iodide, the reflux method is used as suggested by Mudzakir et al. (2008). Substitution of anion is conducted by utilizing the principle of anion metathesis and Lewis basic acids to synthesize cis-oleyl-imidazoliniumacetate.

Compound synthesis process Cis-Oleylmidazolinium-Acetate can be divided into three main stages, they are:

- 1) Synthesis of Cis-Oleil-Imidazolin
  - A total of 20 mmol (2.06 grams) of dietilenatriamina (DETA) and 11.29 grams of cisoleic fatty acid was added to a 100 ml pyrex beaker then stirred until it was evenly distributed. Reactant mixture was irradiated using microwave at 800 watts for 30 seconds, and then cooled to room temperature. After reaching room temperature (25°C), the mixture was transferred into a three-neck round bottom flask which was then added 80 mL ethyl acetate and heated up to 40 ° C (boiling point of ethyl acetate), for 30 minutes. The hot mixture was filtered using a Buchner funnel connected to a vacuum pump then concentrated by evaporator to separate the ethyl acetate solvent. The results were characterized using FTIR instrumentation and its melting point was tested.
- 2) Synthesis of Cis-Oleil-Imidazolinium-Iodida

A total of 1 mole (13.65 grams) of cisoleyl-imidazoline was added with methylene chloride until dissolved and incorporated into the three-neck round bottom flask that had been coated with aluminium foil, added with 2 mol (6.17 grams) of methyl iodide. Subsequently, the mixture was refluxed at a constant temperature of 40°C while stirring it using a magnetic stirrer for 4 hours. The result is cooled down to room temperature, and then dried using a rotatory evaporator at 80°C for 2 hours. Finally, we dried it in a fume hood. The results are characterized using FTIR instrumentation and its melting point was tested.

3) Synthesis of Cis-Oleil-Imidazolinium-Asetat

A total of 10 mmol (7.4390 grams) cisoleylimidazolinium iodide was put in a beaker which had been wrapped in aluminum foil and then dissolved in 100 mL of methanol and added 10 mmol (1.67 grams) of AgCH3COO. The mixture is stirred using a magnetic stirrer for 4 hours. The result was decanted and filtered using a cellulose-nitrate membrane (PTFE). The solvent of the filtrate was then evaporated by stored it in a fume hood until saturated. The results obtained were characterized using FTIR instrumentation and its melting point was tested. Based on the description of the three stages of the synthesis of cis-Oleyl-imidazolinium-Acetate, there were four basic ingredients used: diethylenetriamine, cis-oleic fatty acid, methylene chloride and silver acetate. These materials are related to the content of chemistry class XII on the subject of organic compounds reaction, thus this context can be used to enrich students' knowledge in recognizing chemical materials related with ionic liquids.

b. Structure characterization

To determine the success of the synthesis process stages and the overall synthesis process, we used chemical instrumentation including Fourier Transform Infra Red (FTIR) and melting point test.

1) FTIR analysis

Characterization using FTIR aimed to compare the condition of a sample before and after the process of synthesizing. This analysis used SHIMADZU FTIR-8400. The functional group of the FTIR spectra provided distinctiveness FTIR spectra pattern information of functional groups present in the sample before and after the process of synthesis. Based on the result, we obtained their suitability or peak difference of the functional groups observed in the spectra so that the changes in the structure before and after the process could be explained.

2) Analysis of melting point

Physics properties can be used for qualitative analyzing of a substance. The success of the process of synthesis of a pure solid sample can be characterized by means of determining the melting point.

## Some application of basic ingredients of Cis-Oleyl-imidazolinium

1) Applied as Redox Electrolyte in *Dye Sensitized* Solar Cells (DSSC)

The materials used for the DSSC are: TiO2 powder, Polyvnyl Alcohol (PVA), ethanol, potassium iodide, iodine, and three fatty imidazolinium salt from synthesis result, isolation scotch, conductive glass (indium tin oxide, ITO) and chromophore source material.

In brief, the manufacture of DSSC was shown in Figure 5.

2) Applied as Electrolytes in Artificial Muscle System

The materials used are synthesized cisimidazolium iodide, technical chitosan, technical acetic acid, chlorosulfonic acid p.a, and dimethyl formamide P.A. The procedure of making the raw material of artificial muscle system are briefly shown in Figure 6.

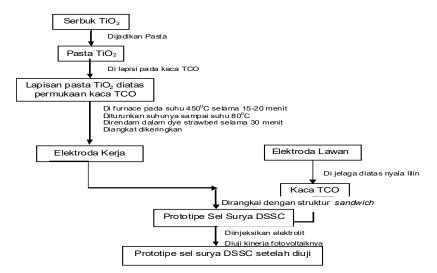


Figure 5. Creating Cis-imidazolium-asetat electrolyte-based DSSC solar cell

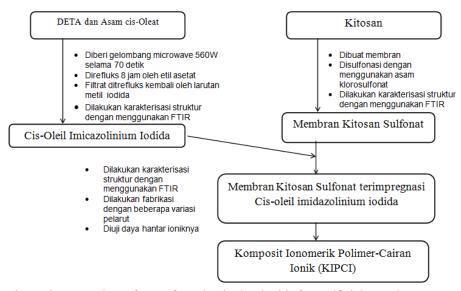


Figure 6. Alternative Procedure of Manufacturing ionic Liquids for Artificial Muscle

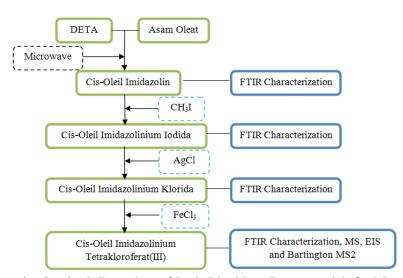


Figure 7. Alternative Synthesis Procedure of Ionic Liquids as Raw materials for Magnetic Lubricant

3) Applying Ionic Cis-Imidazolinium as Magnetic Lubricant

The materials used are: acid cis-oleic extract pure, methyl iodide, dietilenatriamina p.a., methylene chloride technical, ethyl acetate technical, methanol, AgCl pa, iron (III) chloride pa, natural fibre waste, NaOH p.a., and Aquades.

Working procedure system was divided into three processes; the synthesis process of magnetic ionic liquid of cis-oleyl imidazolinium tetrakloroferat (III), the manufacture of natural fibre materials, and the manufacture of magnetic paper with impregnation method. Ionic Liquids Synthesis process was shown in Figure 7.

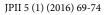
#### **CONCLUSION**

Based on the data, we can conclude: Modernization of chemistry curriculum was required by utilizing the context of modern technology which is the source of knowledge in developing teaching materials. Ionic liquid material is the context that has the potential to be applied in the chemical content in the school. Some of the application of ionic liquids can be used in chemical content, e.g. the use as raw material for the manufacture of solar cells, artificial muscles and magnetic lubricant.

#### REFERENCES

- Awad, W. A., Gilman, J E., Nyden, M., Harris, R. H., Sutto, T. E., Callahan, J., Trulove, P. C., DeLong, H. C. & Fox, D. M. (2004). Thermal Degradation Studies of Alkylimidazolium Salts and Their
- Application in Nanocomposites. Thermochimica Acta, 3 (1), 409-414.
- Bhatt, A. I., May, I., Volkovich, V. A., Hetherington, M. E., Lewin, B., Thied, R. C., dan Ertok, N. (2002). Group 15 Quaternary Alkyl Bistriflimides: Ionic Liquids with Potential Application in Electropositive Metal Deposition and as Supporting Electrolytes. J. Chem. Soc. Dalton Trans, 1 (1), 4532-4542.
- Brennecke, J. F. & Maginn, E J. (2001). Ionic Liquids: Innovative Fluids for Chemical Processing", AIChE Journal. 47 (1), 2384-2390.
- Buzzeo, M.C., Hardacre, C. & Compton, R.G. (2004). Use of Room Temperature Ionic Liquids in Gas Sensor Design. Anal. Chem., 76 (1), 4583-4590
- Davis, J. H., & Fox, P. A. (2003). From Curiocities to Commodities: Ionic Liquids Begin the Transition. Chem. Commun, 1 (1), 1209-1214.
- Earle, M. J. & Seddon, K. R. (2000). Ionic Liquids: Green Solvents for the Future. Pure Appl. Chem, 72 (1), 1391-1400.

- Firman, H. (2007). Laporan Analisis Literasi Sains Berdasarkan Hasil PISA Nasional Tahun 2006. Jakarta: Pusat Penilaian Pendidikan Balitbang Depdiknas.
- Gordon, C. M., Holbrey, J. D., Kennedy, A. R. & Seddon, K. R. (1998). Ionic Liquid Crystals: Hexafluorophosphate Salts. J. Mater. Chem., 8 (1), 2627-2635.
- IOLITEC. (2005). Ionic Liquids. Chemfiles, 5 (6).
- Hagiwara, R. & Ito, Y. (2000). Room Temperature Ionic Liquids of Alkylimidazolium Cations and Fluoroanions. Journal of Fluorine Chemistry, 105 (1), 221-230.
- Hayat, B & Yusuf, S.(2010). Mutu Pendidikan. Jakarta: Bumi Aksara.
- Holbrey, J. D. & Seddon, K. R., (1999). The Phase Behaviour Of 1-Alkyl-3-ethylimidazolium Tetrafluoroborates; Ionic Liquids and Ionic Liquid Crystal. J. Chem. Soc., Dalton Trans, 2 (1), 2133-2140.
- Merrigan, T. L., Bates, E. D., Dorman, S. C. & Davis, J. E. (2000). News Fluorous Ionic Liquids Function as Surfactants in Conventional Room Temperature Ionic Liquids. Chem. Commun, 2 (1), 2051-2060.
- Miao, W. & Chan, T-H. (2006). Ionic-Liquid-Supported Synthesis: a Novel Liquid-Phase Strategy for Organic Synthesis. Acc Chem Res, 39 (12), 897-902.
- Mudzakir, A., Permanasari, A. & Mahiyudin. (2008). The Influence of Social Issue-Based Chemistry Teaching in Acid Base Topic on High School Student's Scientific Literacy. Proceeding of the First International Seminar of Science Education, Science Education Program Graduate School, Indonesia University of Education (UPI).
- OECD. (2013). PISA 2012 Results: What Students Know and Can Do, OECD Publishing.
- Ohno, H. (2001). Molten Salt Type Polymer Eectrolytes. Electrochim. Acta., 46(1), 1407-1415.
- Olivier, H. & Magna, L. (2002). Ionic Liquids: Perspectives for Organic and Catalytic Reactions. J. Mol. Cat. A., 419 (1), 182-183.
- Taush, M.W. & Bohrmann-Linde, C. (2007). Curriculum Modernization in Chemical Education. Proceeding of the 2nd European in Chemistry Education, Prague.
- Toma, G., Gotov, B., & Solcaniova, E. (2000). Enantioselective Allylic Substitution Catalyzed by Pd0–Ferrocenylphosphine Complexes in [Bmim][PF6] IonicLiquid. Green Chem., 2(1), 149-157.
- Vidis, A., Ohlin, A., Laurenczy, G., Küsters, E., Sedelmeier G., & Dyson, P.J. (2005). Rationalisation of Solvent Effects in The Diels-Alder Reaction Between Cyclopentadiene and Methyl Acrylate in Room Temperature Ionic Liquids. Adv. Synth. Catal., 2 (1), 347,266.
- Ye, C., Liu, W., Chen, Y. & Yu, L. (2001). Room Temperature Ionic Liquids: a Novel Versatile Lubricants. Chem. Commun. 1 (1), 2244-2256.





Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# SCIENTIFIC REASONING ABILITY OF PROSPECTIVE STUDENT TEACHER IN THE EXCELLENCE PROGRAM OF MATHEMATICS AND SCIENCE TEACHER EDUCATION IN UNIVERSITY OF MATARAM

# A. W. Jufri\*, D. Setiadi, Sripatmi

University of Mataram Lombok, Indonesia

DOI: 10.15294/jpii.v5i1.5792

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

#### ABSTRACT

The purpose of this study is to investigate the scientific reasoning ability of the prospective student teacher, and to analyze the difference in scientific reasoning ability between students in the study programs. The sample set consisted of 179 students joining the Excellence Program of Mathematics and Science Teacher Education in the Faculty of Teacher Education (FTE) in the University of Mataram. The Classroom Test of Scientific Reasoning (CTSR) was translated into Indonesian language and used to measure the student scientific reasoning ability. The results of this study revealed that 95.5% students had low reasoning ability and were categorized as concrete and transitional reasoner. Only few students (4.5%) reached the category of formal operational reasoner. In addition, significant differences of the students reasoning ability emerged among the third and the fifth semester students, as well as students in the four study programs.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: concrete, CTSR, formal operational scientific reasoning, transition

## INTRODUCTION

One of teaching goals in Sience, Technology, Engineering, and Mathematics (STEM) education is fostering student s' content knowledge and developing general scientific abilities (Bao et al. 2009), and one of the abilities is scientific reasoning. It is a part of cognitive skills required to evaluate scientific information and resolve complex problems (Bao, *et al.* 2009; Lee & She, 2010; Piraksa, et al. 2014). It involves the abilities which have long-term impact accompaniment on student's academic achievement.

The ability to reason scientifically is a reflection of a person's thinking skills about the processes of inquiry which include designing experiments, analyzing scientific evidences, inferencing, evaluating the results of investigation, and understanding the concepts and the complex

\*Alamat korespondensi: Email: awahabjufri@unram.ac.id theories of science (Zimmerman, 2005; Piraksa *et al.* 2011). It is manifested as a strategy of making conclusion based on scientific evidences (Lee & She, 2010), and closely related to cognitive processes in relation to the way of making decisions and the results of academic learning (Kuhn & Dean, 2004; Bao et al. 2009).

Scientific reasoning consists of some aspects that are interconnected as proportions of arguments about probability, relation between two or more variables, and social process to seek the truth based on the theory and scientific evidence (Lawson, 2000; Kuhn, 2004). Several research studies indicate that scientific reasoning ability is necessary for students as to be able to compete in the global era. Therefore, students' performance on scientific reasoning is important to be developed in science teaching and learning process (Chen & Klahr, 1999; Bao et al. 2009) from elementary through college level of education.

Scientific reasoning skills can be developed

through training and transferred in the supporting academic environment (Bao et al., 2009; Piraksa et al., 2011). Training in scientific reasoning has a long term impact on student academic achievements. Therefore, the STEM education community considers that transferable general abilities are at least as important for students to learn as is the content knowledge (Bao et al. 2009). Undergraduate students and science teachers in secondary schools should have the valuable attributes of scientific reasoning (Tajuddin et al., 2012). However, the majority of undergraduates are lack of advanced reasoning patterns, which are necessary for significant achievement in college science courses (Deamfle, 2006). Science teachers and prospective student teachers in college should have the strategies to train and transfer scientific reasoning skills to students (Johnson & Lawson, 1998). Mathematics and science teachers should develop scientific reasoning ability of middle school students as a component of the 21st century skills (Annetta et al., 2010; Piraksa et al., 2014). To support the that process, prospective student teachers in college especially in the faculty of teacher education (FTE) in the University of Mataram must be facilitated to develop their reasoning ability. The purposes of the research are to: (1) identify the scientific reasoning ability of prospective student teacher who were in the Excellence Program of Mathematics and Science Teacher Education (EPMSTE) in the FTE, University of Mataram, and (2) to analyze the differences of scientific reasoning ability of third and fifth students semester as well as in the four Study Programs in the academic year 2012/2013.

#### **METHOD**

The research was conducted during September to November 2013/2014 in the Department of Mathematics and Science Education of FTE in University of Mataram. The subjects of the research consisted of 179 prospective student teachers in the third and fifth semester. The instrument used to collect the data of this study is the test of scientific reasoning which is translated from the Classroom Test of Scientific Reasoning (CTSR) developed by Anton E. Lawson (2000). The test consists of 24 items or 12 pairs of items with four alternative answers. Odd-numbered test items contain the statement about the cause of an event/natural phenomenon and the evennumbered test items are the alternative reasons' arguments which support the answer chosen. The CTSR has been used worldwide and proven to be able to measure student's concrete and formal operational thinking abilities in secondary level and higher education (Lawson, 2000; Bao, et al. 2009, Piraksa, et al. 2014). This test serves to measure student's ability to reason and to think proportionally, probabilistically, correlationally and hypothetico-deductively. The reliability of the test items is 0.78. Data were analyzed with the One-way Analysis of Variance (ANOVA) by SPSS computer program.

#### **RESULT AND DISCUSSION**

The average score of students' scientific reasoning ability ranged from 22.45 to 38.25. The lowest average scores (Mean 22.45) obtained by the students of the third semester of Biology Education Study Program and the highest average scores (Mean: 38.25) obtained by the fifth semester students of Mathematics Education. In detail, the average scores of student scientific reasoning ability are presented in Table 1 and the student distributions based on their level of reasoning ablity are shown in Table 2.

Referring to the average score of students reasoning ability as shown in Table 2, it can be stated that most of the students of the EPMSTE University of Mataram is still in the category of concrete operational and transitional thinking (95.70%), and only 4.30% students reached the formal operational thinking. This condition indicates the weakness of the prospective student teachers reasoning ability. According to Lawson (2004), based on their reasoning ability, learners can be classified as concrete operational reasoner (score 0-30), transitional reasoner (score 30-70), and reflective or formal operational reasoner (score 80 - 120).

Moore & Rubbo (2011) stated that the students classified as mostly concrete operational reasoner are characterized by their appropriate use of logic. However, they struggle with solving problems outside of a concrete context, demonstrating significant difficulty with abstract concepts and hypothetical tasks. Formal operational reasoner begins to think abstractly, reason logically, and draw conclusions from available information. Unlike the concrete operational reasoners, the formal operational reasoners are able to apply appropriate logic to hypothetical situations in most contexts. In this way, formal operational reasoner can begin to think like a scientist, and specifically develops srong hypothetico-deductive reasoning. Transitional reasoner falls between the other two classifications where they find success with hypothetical tasks in some contexts. Formal operational thinking skill develops gradually bet-

	Study program/semester							
	Biology Chemistry Physics						Math	ematics
	3rd	5th	3rd	5th	3rd	5th	3rd	5th
Ν	22	22	25	21	19	22	27	20
Mean	22.45	26.54	27	23.54	30	28.95	32.44	38.25
Min	8.00	8,00	8.00	8.00	8.00	8.00	16.00	8.00
Max	4.,00	58	58.00	50.00	50.00	58.00	66.00	66.00
StDev	11.42	14.67	14.54	14.83	10.13	15.17	13.05	13.72

 Table 1. Distribution of Mean Scores of Students Scientific Reasoning

Table 2. Student Distributions A	ccording to Their	Levels of Reasoning Abilities

Study Programs	Ν	Percentage of Students in each Level of Reasoning Ability		Total Percentage	
		COR	TR	FOR	
Biology	44	12.3	12,3	0.5	25.1
Chemistry	47	9.4	15	1.3	25.7
Physic	41	4.2	17	1,4	22.6
Mathematics	47	3.2	22,3	1,1	26.6
		29.10	66.60	4.30	100

Note: COR: concrete operational reasoner, TR: transitional reasoner, FOR: formal operational reasonerv

ween 11-18 years of age and results in a refinement or perfection of operations developed at the concrete stage (Valanides, 1997). The third and fifth semester of college students should have developed the skill, in fact this study shows the contradictive reality. This fact should become a valuable condition to evaluate and improve the model of teaching and learning process, especially in the Department of Mathematics and Science Education of FTE in University of Mataram.

The students' scientific reasoning scores differ significantly between semesters and the study programs (p < 0.05) as shown in Table 3. Data regarding the difference in the average scores as well as the level of significance of differences between study program and semester are presented in Table 4.

The data in Table 4 show the differences in the level of reasoning ability between groups and between semesters. The reasoning ability of the 3<sup>rd</sup> semester students in the Biology Education Program differs significantly from that of the students in the Physics Education Program and Mathematics as well as the 5<sup>th</sup> semester. The 5<sup>th</sup> semester studens of Biology only differs significantly from the students in the Mathematics Education Program, and the students of the 5<sup>th</sup> semester in the same study program also significantly differ from the students in the third semester Chemistry Education Program and in both semester of student in the Physics Education Program. The difference in scores of reasoning ability between other groups of students was not significant (p > 0.05).

The results of this study are consistent with the statement of Piraksa, et al., (2014) who found that university students in Thailand mostly think unscientifically. The scientific reasoning ability of the prospective student teachers in University of Mataram really needs attention to be developed through the improvement of the quality of teaching and learning processes. This is in line with the opinions of Piraksa, et al. (2014) which suggested that teaching plans should be designed to support the development of the students scientific reasoning ability. Some relevant models of learning include discovery, inquiry-based, problem-based, and computer-based learning models (Lawson, 2004; Bao et al. 2009; Tajuddin, et al. 2012; Piraksa, et al. 2014). Bao, et al. (2009) quoted the statements of Benford & Lawson, (2001) and Gerber, et al. (2001) that scientific reasoning abilities of students in any level of education can be developed through the implementation of inquiry-based learning. Johnson and Lawson (2004) found that the scientific reasoning and prior knowledge of students taught by inquiry model were higher than those of students taught by exposi-

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3874.042	7	553.435	3.123	$0.\bar{0}04$
Within Groups	29768.180	168	177.192		
Total	33642.222	175			

**Table 3.** ANOVA Test Results for the Scientific Reasoning Ability Mean Scores of Student Teacher

 Candidates based on the Sudy Programs

	Table 4.	The Difference of	of Students'	Scientific	Reasoning	Ability	within	Study Programs
--	----------	-------------------	--------------	------------	-----------	---------	--------	----------------

I (SP-SMT)	J (SP-SMT)	Mean Difference	Std. Error	Sig.
Biology smt 3	Physics smt 3	-8.65072*	4.16894	.040
	Physics smt 5	-8.32806*	3.96965	.037
	Mathematics smt 3	-11.98990*	3.82319	.002
	Mathematics smt 5	-17.79545*	4.11263	.000
Biology smt 5	Mathematics smt 5	-11.70455*	4.11263	.005
Chemistry smt 3	Mathematics smt 5	-10.12500*	4.03021	.013
Chemistry smt 5	Mathematics smt 5	-11.40789*	4.26444	.008
Physics smt 3	Biology smt 3	8.65072*	4.16894	.040
	Mathematics smt 5	-9.14474*	4.26444	.033

tory approach. In this regard, Jufri (2007) found that inquiry-based learning model can improve students' critical thinking skills. Through these models of teaching and learning, students can involve in the process of scientific observation, actively provide explanations, and test their ideas based on scientific evidences accompanied by logical arguments and positive interaction with their colleagues (Lawson, 2004).

Bao, et al. (2009) proved that the middle school students in China who learned Physics with training (drill) methods can improve their ability in problem solving, but the same methods does not give significant effect on students scientific reasoning ability. Chin & Osborne (2010) found that there is a positive correlation between the number and the quality of questions, and the quality of written arguments raised by students whose mastery concepts of the subject matter. Therefore, facilitating the development of scientific reasoning ability in science teacher training program is quite urgent to give the opportunity for future teachers to build their own tools that permit them to promote reasoning skills for their students (Archila, 2014).

Even though the reasoning abilities of students tested with CTSR look simple for experts, in fact this is a fundamental component that is quite crucial to support the development of other capabilities that are more vital and more complex (Bao et., 2009). The ability to reason is very important to support other aspects of higher order thinking skills. Lawson (2004) states that the scientific arguments are hypothetico-deductive in structure and consist f some aspects that are interconnected including the proportion of arguments, control of variables, arguments about probability and arguments regarding correlation between variables.

An ultimate goal of higher education is to prepare our future workers with needed knowledge and skills. This includes cultivating students to become proficient reasoner who can utilize proper scientific reasoning to devise causal inferences from observations (Ding et al. 2014). Reasoning ability of students should be the main purpose of the college curriculum that focuses more on the development of learners mathematics and science literacy (Piraksa, et al. 2011). Supposedly, undergraduate or college level students should have been able to reason scientifically and to think reflectively with hipotetico-deductive pattern. However, the results of this study shows that most students in the Department of Mathematics and Science Education of the FTE in University of Mataram are still possessed low reasoning ability. This condition relates to the findings of Jufri & Hikmawati (2012) which show that many science teachers in Lombok have low reasoning ability and also low scientific literacy. These facts are of considerable concern and need to be addressed seriously. If the student teacher reasoning ability

is low, then of course and it will closely linked to their pattern of teaching if one day become a teacher.

Based on the findings of this study, it is suggested that the pedagogy of learning science for prospective student teachers should be directed to the learning patterns of (1) how to construct reason based on hypotheses and scientific evidence, (2) how to design a good science experiments, and (3) how to determine the correlation between target variables in order to support the development of student scientific reasoning capabilities. In other words, the faculty has to offer continuous reform to promote education quality. Education reform should be interpreted as an effort to create programs that focus on improving teaching and learning practices, not solely focused on designing a class with a teacher-proof curriculum. Thus, teaching practices actually intend to avoid the problems faced by students in the learning process. Learning practices can be developed through the evaluation and development of teachers' mastery of the subject matter and the way teachers learning to pack and carry the lesson. To that end, it is necessary for teachers' professional development program to provide opportunities to learn how to learn some vital lessons (learning how to learn), and learn how to teach (learning about teaching). Thus, it is essential to get the attention of the faculty staffs especially lecturers in order to facilitate the development of student ability to reason and skills in science literacy (Schen, 2008). In order to develop the capability of prospective student teachers, the teaching and learning processes in the faculty should be directed to deliver students to have scientific reasoning skills to supports scientific literacy. Of course, lecturers within the FTE in the University of Mataram need to design and to implement teaching models that challenge students to think critically and creatively such as inquiry-based, project based, and problem based learning models.

#### **CONCLUSION**

Based on the results of research and discussion above, it can be concluded that: (1) the scientific reasoning ability of the prospective student's teacher in the FTE of University of Mataram is categorized as low. More than 90% students are classified as concrete and transitional reasoners. Only 4.3% students reached the formal operational phase of thinking; and (2) there is a significant difference in the aspects of the student's scientific reasoning ability within semester and within study programs.

#### ACKNOWLEDGEMENTS

The authors wish to acknowledge the Excellence Program of Mathematics and Science Teacher Education, theFaculty of Education, Mataram University, Indonesia, for a financial support and opportunities in conducting the research and presenting this paper.

#### REFERENCES

- Annetta, L.A., Cheng, M. T. & Holmes, S. (2010). Assessing Twenty-first Century Skills through a Teacher Created Video Game for High School Biology Students. *Research in Science & Technological Education*, 28 (2), 101–114.
- Archila, P. A. (2014). Are Science Teachers Prepared to Promote Argumentation? A Case Study with Pre-service Teachers in Bogotá city. Asia-Pacific Forum on Science Learning and Teaching, 15 (1). Retrieved from: http://www.ied.edu.hk/apfslt/ download/v15\_issue1\_files/archila.pdf.
- Bao, L., Cai, T., Koenig, K., Fang, K., Han, J., Wang, J., Liu, Q., Ding, L., Cui, L., Lou, Y., Wang, Y., Li, L. & Wu, N. (2009). Learning and Scientific Reasoning. *SCIENCE*, 323 (1), 586-587.
- Chen, Y. & Khlar, D. (1999). All Other Thing being Equal: Acquisition and Transfer of the Control of Variable Strategy. *Child Development*, 70 (5), 1098-1120.
- Chin. C. & Osborne, J. (2010). Students' Questions and Discursive Interaction: Their Impact on Argumentation during Collaborative Group Discussion in Science. *Journal of Research in Science Teaching*, 47 (7), 883-908.
- Deampfle, P. A. (2006). The Effects of Instructional Approaches on the Improvement of Reasoning in Introductory College Biology: A Quantitative Review of Research. Retrieved from: http://files.eric.ed.gov/fulltext/EJ854249.pdf.
- Ding, L., Xin, W. & Katherine, M. (2014). Does Higher Education Improve Student Scientific Reasoning Skills? *International Journal of Science and Mathematics Education*. Retrieved from: http://link.springer.com/article/10.1007%2Fs10763-014-9597-y
- Johnson, M. A. & Lawson, A. E. (1998). What are the Relative Effects of Reasoning Ability and Prior Knowledge on Biology Achievement inExpository and Inquiry classes? *Journal of Research in Science Teaching*, 35 (1), 89-103.
- Jufri, A.W. (2007). Pengaruh Implementasi Perangkat Pembelajaran Berbasis Inkuiri Melalui Strategi Kooperatif Terhadap Keterampilan Berpikir Kritis, Sikap, dan hasil Belajar Kognitif Siswa SMA di Kota Mataram. Disertasi), Malang: Program Pascasarjana Universitas Negeri Malang.
- Jufri, A.W. & Hikmawati. (2012). Analisis Kemelekan Sains (Science literacy) dan Kemelekan Inkuiri (Inquiry literacy) Guru Pelajaran IPA di Lombok. Laporan Penelitian Strategis Nasional.

- Kuhn, D. (2004). "What is Scientific Thinking and How does it Develop?" In U. Goswami (Ed.), Handbook of Childhood Cognitive Development (Blackwell) (2nd ed., 2010). Retrieved from: http:// www.dk100/faculty-profile/files/10\_whatisscientificthinkingandhowdoesitdevelop.pdf.
- Kuhn, D. & Dean, D. (2004). Metacognition: A Bridge Between Cognitive Psychology and Educational Practice. *Theory Into Practice*, 43 (4), 268-273.
- Lawson, Anton E. (2004). The Nature and Development of Scientific Reasoning: a synthetic view. International Journal of Science and Mathematics Education. 2 (1), 307-338. Retrieved from: http://link.springer. com/article/10.100 7%2Fs10763-004-3224-2#/page-1
- Lee, C. & She, H. (2010). Facilitating Students' Conceptual Change and Scientific Reasoning Involving the Unit of Combustion. *Research in Science Education*, 40 (1), 479–504.
- Moore, J. C. & Rubbo, L. J. (2011). *Scientific reasoning abilities of non-science majors in physics-basedcourses.* Retrieved from: arXiv:1110.2764v1 [physics. ed-ph]. On 2 August 2015.
- Piraksa, C., Peempond, P., Romklao, A. & Niwat, S. (2011). Exploring Scientific Reasoning Ability in Thai University Students: A CaseStudy of KhonKaen University, Thailand. ICER 2011: Learning Community for Sustainable Develop-

ment: September 9-10. KKU, Thailand.

- Piraksa, C., Niwat, S. & Rekha, K. (2014). Effect of Gender on Students' Scientific Reasoning Ability : A CaseStudy in Thailand. *Procedia-Social* and Behavioral Sciences, 116 (1), 486 – 491.
- Schen, M. (2008). Scientific Reasoning Skills Development in An Introductory Biology Course Sequence for Undergraduates, Paper at the NARST Annual Conference Baltimore, MD, Macrh 30 – April 2: 2008.
- Tajuddin, M. N., Noorshah, S., Nurulhuda A. R., Asmayati Y., Hasimah A., Dollah, M. U. & Karim, M.M. (2012). Mapping the Level of Scientific Reasoning Skills to Instructional Methodologies among Sciences, Mathematics and Engineering Undergraduates. *International Journal of Humanities and Social Science*, 2(3), 5-11.
- Valanides, N. (1997). Formal Reasoning Abilities and School Achievement. *Studies in Educational Evaluation*, 23 (2), 169-185.
- Zimmermann, C. (2005). The development of Scientific Reasoning Skills: What Psychologist Contribute to an Understanding of Elementary Science Learning. Retrieved from: http://sites.nationalacademies.org/cs/ groups/dbassesite/documents/ webpage/dbasse\_080105.pdf



JPII 5 (1) (2016) 75-82

Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# THE EFFECT OF MULTIMEDIA-BASED TEACHING MATERIALS IN SCIENCE TOWARD STUDENTS' COGNITIVE IMPROVEMENT

# Khoiriah<sup>\*1</sup>, Tri Jalmo<sup>2</sup>, Abdurrahman<sup>2</sup>

<sup>1</sup>SMP Negeri 16 Bandar Lampung, Indonesia <sup>2</sup>Prodi Pendidikan Fisika, FKIP, Unila Bandar Lampung, Indonesia

DOI: 10.15294/jpii.v5i1.5793

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

#### ABSTRACT

This study is a meta-analysis study that aimed to determine the effect of multimedia-based teaching materials in science learning to students' cognitive enhancement. This study integrated primary study results of several studies that had been published in national and international journals. The method used in this research was the analysis of the results of seven international journals and three national journals involving multimedia teaching materials based on science learning as the main study. Searches were done through the search engine Google, using Eric Journal and Google scholar with keyword multimedia-based teaching materials. Analysis of data was the description of the results of the average effect size of each study sampled then categorized based on Cohen's interpretation. The results showed that multimedia-based teaching materials in science learning had a significant influence on students' cognitive learning outcomes indicated by the average effect size of 0.78. Differences in cognitive enhancement were based on a group of countries, fields of study, education level and the variety of multimedia teaching materials. It was concluded that the multimedia-based teaching materials in science learning showed a significant effect on students' cognitive enhancement.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: meta-analysis, multimedia teaching materials, students' cognitive.

## INTRODUCTION

Natural Science is a vehicle for students to learn about objects and natural phenomena based on the thoughts, observations and investigations (Ministry of Education and Culture, 2014). Science does not only cover scientific knowledge, but also contains important scientific dimensions that includes content dimension in the form of facts, concepts, laws and theories, and the dimensions of the scientific process (Liliasari & Tawil, 2014).

Science is a knowledge to develop scientific understanding through research activities, so that students are able to explain, evaluate and build scientific knowledge independently (Duschl, et al., 2007).

The quality of science teaching in some

\*Alamat korespondensi: Email: khoiriahspd74@gmail.com countries, at the moment is still relatively low. This is reflected in the results of the analysis of the ability of students' science achievement in several international studies such as TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Students Assessment). Based on the TIMSS science achievement data mapping in 2011, there were 24 of the 42 participating countries are in a position below the international average score scoring less than 500 (IEA, 2012). Furthermore, based on the results of PISA in 2012 there were 40 of the 65 participating countries also had an average science achievement scores below the international average score under 501 (OECD, 2013).

The low achievement in science in some countries is partly due to the less maximal of students' cognitive abilities development. Cognitive ability is not a natural skill but a process and a product of mind to attain knowledge in the form of mental activities like remembering, symbolizing, categorizing and solving problems (Hamalik, 2011). Cognitive Domain in Bloom's Taxonomy mentions six kinds of capabilities that are arranged in a hierarchy ranging from the simplest to the complex, they are: knowledge, comprehension, application, analysis, synthesis and evaluation (Vieyra, 2006). One cause of low cognitive abilities of students is the teaching materials used in teaching (Djamarah & Zain, 2014). Many teaching materials only copy information from one of to others, so that students have a tendency to memorize. Teachers need appropriate media to attract students' attention during learning, processing complicated and complex teaching materials into simple and clear ones, and reverting abstract scientific concepts into the concrete ones (Ministry of National Education, 2007). Concrete concepts in learning become fundamental to clarify the abstract facts (Hill & Korhonen, 2014). Attractive teaching materials are potential to increase the students' cognitive processes (Koning, et al., 2009). The effectiveness and efficiency of the learning process can be improved through the application of multimedia teaching materials (Siagian, et al., 2014).

Multimedia includes various combinations of text, images, graphics, animation and video elements that have been digitally manipulated so as to display a fun projection, having aesthetic value and maintaining visual consistency (Ivers & Baron, 2010). Students receive multimediabased learning information through both spoken and text as well as information through images such as animations or illustrations (Mayer, 2003). Application of multimedia learning can increase high-level thinking skill, problem solving skill and students' cognitive (Stoney & Oliver, 1999). Multimedia greatly contributes to the effectiveness of learning as well as the delivery of messages and content, thus helping students to enhance their understanding and ability to think (Fitriana, 2011).

Research on multimedia learning has been widely carried out, thus requiring a comprehensive assessment. This study aimed to determine the effect of multimedia-based teaching materials in science learning toward students' cognitive improvement. It was conducted through several discussions in general, regional countries, subjects, education levels and learning media.

#### **METHOD**

The method in this study was a meta-analysis by reviewing the results of several educational journals (Merriyana, 2006). The collection of data obtained from 10 journals on education includes seven international journals and three national journals, while the journals were searched through google search engines included Eric Journal and Google Scholar with the main study of multimedia-based teaching materials.

Analysis of the data used a description of the average effect size of each study. The applied formula of effect size was Delta Glass (Glass, 1976). The effect sizes results was then categorized based on Cohen's interpretation as follows:

Table 1. Category of Effect Size

Cohen's Standard	Effect Size
Large	0,6-2,0
Medium	0, 3-0, 5
Small	0,0-0,2
Cohen (1988)	

#### **RESULT AND DISCUSSION**

The discussion in this research comprehensively covers general study, regional countries, science disciplines, education levels and learning media.

Based on data from Table 2, it showed that the average effect size was 0.78. This shows that the multimedia-based teaching materials in science learning can improve cognitive achievement of students with the category of "high" (Cohen, 1988). Learning by using multimedia-based teaching materials make it easier for students to understand the concept (Zahra, 2015). Students can learn the abstract concepts using multimediabased teaching materials so as to clarify those (Ministry of National Education, 2007). Multimedia-based teaching materials can improve the construction of knowledge, synthesis skill as well as build bridges between knowledge (Schrader & Raff, 2015). Abstract concepts in physics will be more easily understood when students acquire multimedia learning (Liu 2006 & Wiyono, 2009).

The results of analysis of multimedia teaching materials presented through a variety of ways, including text, graphics, images, audio, video and animation (Table 2). Students will learn more effectively when learning information is processed through various means (Rahman, 2011). The concept of liver function is easier to understand when students use multimedia graphics, while the blood circulation system is presented in text, video and animation (Brunken et al., 2003). Presentation of learning informati-

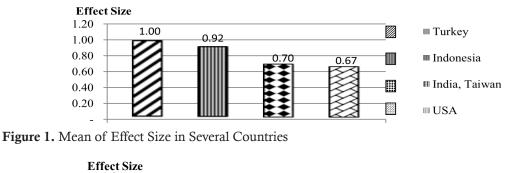
Tubh								Total	Effect
No.	Researcher	Country	Sub- jects	Level	Experiment	Control	Discussion	Respon- dents	Size
1.	Li Zhu and Barbara Grabowski	Pennsyl- vania	Biology	Senior High School	Animation & Elabora- tion Strategy	Graphic Pictures	Concept Understand- ing	115	0,30
2.	Bradley D. Ausman, Huifen Lin, dan Kusro Kidwai	Pennsyl- vania	Biology	Uni- versity	Proggresive Animation	Anima- tion	Concept Understand- ing	88	0,80
3.	Carol Ko- roghlanian dan James D. Klein	Arizona	Biology	Senior High School	Audio – Animation	Audio Text	Concept Understand- ing	109	0,5
4.	Wira Udaibah	Indonesia	Chem- istry	Uni- versity	Animation – Power Point	Conven- tional	Achieve- ment and Learning Motivation	40	0,92
5.	Gokhan Aksoy	Turki	Physics	El- emen- tary School	Computer Animation	Tradi- tional	Learning Outcomes	60	1,00
6.	Slamet Ra- hayu, Wardi dan Sucipto	Indonesia	Biology	Junior High School	Flash Ani- mation	Power Point	Learning Outcomes	64	0,65
7.	Ananta Ku- mar Jena	India	Biology	El- emen- tary School	Computer Animation	Tradi- tional Teach- ing	Learning Outcomes	52	0,84
8.	Agnaldo Pedra, Richard E. Mayer dan AlbertoLuiz Albertin	Brazil	Physics	Uni- versity	Interractive Technic Animation	Non- Inter- ractive	Learning Outcomes	68	1,06
9.	Hsin I.Yung dan Fred Pass	Taiwan	Biology	Junior High School	Pedagogic Animation	Non- Peda- gogic Anima- tion	Cognitive Mastery	133	0,53
10.	I Nyoman Haryanto	Indonesia	Biology	Special Needs Junior High School	Animation Video	Tradi- tional	Learning Outcomes and Creativ- ity	20	1,19
	Mean								0,78

**Table 2.** Characteristic of Research Data and Effect Size.

on through text, graphics, images, audio, video and animation also relates to the use of the five senses. Students' understanding will be better if the lesson presented by integrating the senses of sight and hearing compared by only using the sense of sight (Mayer, 2001).

Results of research by Haryanto (2015) involved students of junior high school with special needs as a sample. This research has the highest effect size (1.19) compared to other research (Table 2). Characteristics of his study sample are below normal students with the Intelligence Quotient (IQ) of less than 79 (Somantri, 2006). Teaching materials in Haryanto's research (2015) were presented through video animation on the concept of the body frame and the human senses. The results showed that an animated video teaching material can improve cognitive learning outcomes of students. Animated video teaching materials are more capable to stimulate thoughts, feelings, concerns and learning willingness of students (Ministry of National Education, 2007). Multimedia teaching material can input and exchange various types of information and knowledge into students' minds more widely (Jalali, et al., 2015). Learning effectiveness can be maximized through multimedia learning (Najjar, 1998).

The results of data analysis also showed the influence of multimedia teaching materials to students' cognitive improvement in several count-



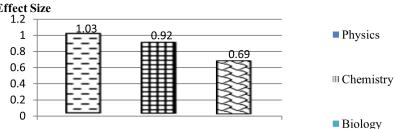


Figure 2. Means of Effect Size on Science Subjects

ries including Indonesia, USA, Turkey, India and Taiwan.

The average effect size of influence of multimedia teaching materials toward students' cognitive enhancement in Indonesia and Turkey were higher than the US, India and Taiwan (Figure 1). This was due to the control class research in Indonesia and Turkey used different teaching materials from the experimental class. Control classes were not given multimedia-based teaching materials so that it gives a very significant effect on students' cognitive enhancement. Multimedia developments in Indonesia started since the erection of Satelindo in 1993. This progress was marked with the publication of 2210 of multimediabased educational journals. Meanwhile, based on the results of the data mapping by PISA in 2012, Turkey ranked 44th out of 65 participating countries (OECD, 2013). This fact had pushed the Turkish government to reform the education (Gencer & Cakiroglu, 2005; Dogan & El Khalick 2008 and Cikmaz, 2014).

Based on the facts, it was concluded that the multimedia development in Indonesia and Turkey used new technology. Through new learning climate, Indonesia and Turkey are capable of increasing students' interest and motivation, thus providing a positive influence on the learning outcome (Djamarah & Zain, 2014). Motivation is the driving engine that can accelerate the success of the learning process (Hamalik, 2011).

Meanwhile, the control classes in various researches of India, Taiwan and the USA were also applied multimedia-based teaching materials (e.g. images, graphics, animation and audio) and therefore it contributed less significant to increase students' cognitive, characterized by low average of effect size (Figure 1).

Multimedia systems of USA began in the late 1980s with the introduction of Hypercard by Apple. The progress of multimedia in USA has been marked by the issuance of 16,600 multimedia-based research journals. Developed countries like USA had reformed scientific education in the end of last century (NRC, 1996). Based on these facts, we can conclude that multimedia system in USA was often used in the learning process, but it caused students to feel bored since the multimedia used repetitively, thus lowered students' interest towards learning. Learning with interest will encourage students to learn better than learning without interest (Hamalik, 2011). Learning interest is able to encourage the emergence of student motivation to learn. Motivation affects the process of interaction between students and learning materials (Sardiman, 2014). Students' progress in learning motivation is an important element that involves mental and physical activity (Johnsto, 2013 & Naor, et al., 2014).

The results of data analysis also showed the influence of multimedia-based teaching materials to students' cognitive enhancement in various disciplines of science: physics, chemistry and biology (Figure 2).

Based on Figure 2, it was discovered that the means of effect size of influence of multimedia teaching materials toward physics, chemistry and biology, belongs to the "high" category (Cohen, 1988). Physics materials in these studies were the solar system and engineering, the chemistry material was metal structures and the biology materials included parts and functions of

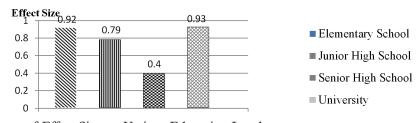


Figure 3. Means of Effect Size on Various Education Level

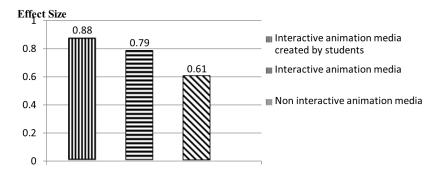


Figure 4. Means of Size Effect of Various Media

the human heart, the circulatory system, the cycle of blood pressure, cell system, digestive system, the body frame and the five senses as well as the human cardiovascular system. Based on above data, it showed that the subject matter of physics, chemistry and biology were mostly abstract concepts. Learning to use the abstract concepts in general the students could only imagine the existence of the matter. Most of students are not able to construct knowledge and understand the material independently so they fail to learn (Hill & Korhonen, 2014). Students' understanding of abstract concepts can be found out through the provision of open-ended questions (Wang, et al., 2012). Teachers play an active role as a facilitator to facilitate students to learn and develop the knowledge (Mahfouz, 2012). Teachers can process abstract concepts through multimedia-based teaching materials into a concrete concept (Ministry of National Education, 2007). Abstract concepts in biology materials will be more easily understood when students use multimedia learning (Pratiwi, 2011).

Various concepts, principles and theories of science are essentially a product obtained through systematic and planned process (Curriculum and Book Research and Development Center, 2014). The concepts of science in general are interconnected; so as to understand a concept, the students first should understand the previous concept. Multimedia teaching materials can help students in describing relationships between concepts and the process of science (Ministry of National Education, 2007).

Based on Figure 3, the effects of multimedia teaching materials in elementary education level students gained an average of 0.92 effect size category "high" (Cohen, 1988). This showed that the multimedia-based teaching materials have a very significant effect on cognitive enhancement of elementary students.

Based on Piaget's Theory of Cognitive Development, students aged 7 to 12 years old are at the stage of concrete operations, so that the students are able to solve the problem logically with the help of concrete concepts and objects (Huitt & Hummel, 2003).

Learning must be tailored to the students' level of cognitive development, for example in the stage of concrete operations the students should learn with the materials that constitute live experience as well as the problems and concrete objects (Sungur et al., 2001). Internal mental activity during the learning has enabled students to modify and organize images and symbols in order to reach logical conclusion (Shaffer & Kipp, 2010).

Figure 3 also showed the multimedia teaching materials on the SMP had "high" category by effect size of 0.79 (Cohen, 1988). Junior high school students (12 to 15 years old) are at the stage of cognitive development of concrete operations towards formal operations (Huitt & Hummel, 2003). Learning using multimedia-based teaching materials can develop their intellectual ability to think on concrete objects (Ministry of National Education, 2007). Effect size for junior high school students was smaller than those for elementary school students (Figure 3). There are still many 12 years old students and older who have not yet reached the stage of formal operations, this happens because of the level of intellectual development is not only determined by the age factor alone but also influenced by maturity, physical experience, math-logic experience, social transmission and the process of balance or self-regulation (Dahar, 1996).

The average of effect size of multimedia teaching materials at high school students was 0.40 (Figure 3). The data was categorized as "moderate". This meant that multimedia teaching materials do not significantly influence the cognitive development of high school students. High school students (15 to 18 years old) are at the mid-teens stage, which is a transition stage between early adolescents aged 12 to 15 years and the late teen aged 18 to 21 years (Yusuf 2008).

Based on Piaget's Theory of Cognitive Development, senior high school students are at the stage of formal operations. In this stage, students are able to think logically for different types of hypotheses, verbal problems, deductive and inductive thinking and the use of scientific reasoning and they are also capable to accept the views of others (Huitt & Hummel, 2003). High school students do not only have the ability to think on a concrete concept, but they can also develop the ability to think in abstract concepts (Krause, et al., 2007 & Sungur, et al., 2001). High school students in general have a higher intellectual development than junior high school students, so they should have a better mastery of concepts. But the results of data analysis showed that the average effect size of high school students is lower than junior high school students (Figure 3). High school students have the cognitive abilities that are well developed to be able to cope with stress or emotional fluctuation effectively. But in reality there are many high school students who have not been able to manage their emotions, depressed, grumpy and less capable to regulate themselves. These conditions lead to various problems, including learning difficulties that affect the improvement of students' cognitive abilities (Yusuf, 2008).

Based on Figure 3, the data analysis the average effect size level of the university students was 0.93. This data is categorized as "high" (Cohen, 1988). This showed that the multimediabased teaching materials play very significant influence on student cognitive enhancement. Students at the university level are at the stage of late adolescence between 18 to 21 years old (Yusuf, 2008).

Based on Piaget's Theory of Cognitive Development, students at the university level belong to the stage of formal operations (Huitt & Hummel, 2003). Mastery of biology concepts at the development level of formal operations is significantly better than students at the level of concrete operations (Okoye, et al., 2008).

The average effect size data showed that university level has the highest score. It is not only related to age alone but it is also determined by the intellectual development, a way of thinking based on the awareness and skill to test hypotheses and scientific reasoning (Yusuf, 2008).

In general the media in this study belonged to the audiovisual motion media or animation (Figure 4). Audiovisual media can show an element of sound (audio) and moving images (visual) (Djamarah & Zain, 2014). Multimedia program includes several important elements include text, images, video, animation, sound, interractive and user controls (Ivers & Baron, 2010).

Multimedia type in this study was interactive multimedia (picture 4). Interactive multimedia was equipped with a controller operated by a computer user to select the desired effect to continue the process of the next program.

The results of data analysis showed that the average effect size interactive animations media created by students was higher than other media, with a score of 0.88 (figure 4). This shows that interactive animation media made by the students has significant effect on students' cognitive improvement compared to other media. Interactive multimedia can increase effectiveness and efficiency of learning (Siagian, et al., 2014). It can also illustrates various concepts to achieve specific learning objectives (Ferguson et al., 2015).

Learning activities of students through interactive multimedia activities is not just a viewing activity, but also a variety of other activities such as listening, observing and discussing, so that the students' knowledge increased significantly (Ministry of National Education, 2007). The data even showed that interactive media created by the students would have a higher effect size than the ones created by the teacher. The best way to study is through speaking activity which contributes to 90% in terms of the understanding, while the activity of talking accounts for 70%, seeing and hearing contribute 50%, the viewing activity helps 30%, hearing gives 20% while reading adds only 10% of the student's total understanding (Magnesen, 1983).

#### CONCLUSION

Based on the analysis, the researcher concludes that:

a. Multimedia teaching materials emerged a very significant influence on students' cognitive

improvement with the effect size of 0.78.

- b. Multimedia teaching materials caused a very significant influence in Indonesia and Turkey with the effect size of 1.00 and 0.92.
- c. Multimedia teaching materials gave the most significant effect on the subjects of physics with the effect size of 1.03.
- d. Multimedia teaching materials brought a very significant influence on the university level, with the effect size of 0.93.
- e. Interactive media created by students played more significant effect on students' cognitive improvement with the effect size of 0.88.

#### REFERENCES

- Abdurrahman. (2011). Penggunaan Multipel Representasi pada Penyusunan Argumen untuk Meningkatkan Penguasaan Konsep Fisika Kuantum. Jurnal Penelitian Pendidikan IPA, 5(1), 8-14.
- Brunken, Roland., Plass, L.Jan & Leutner, Detlev. (2003). Direct Measurement of Cognitive Load in Multimedia Learning. Germany: Departement of Psychology Erfart University.
- Cikmaz, Ali. (2014). Examining Two Turkish Teacher's Questioning Pattern in Secondary School Science Classroom. Lowa: University of Lowa.
- Cohen, Jacob. (1988). *Statistical Power Analysis for The Behavioral Sciences (2nd ed)*. Hillslade. NJ: Lawrence Erlbaum Associates.
- Dahar, Ratna Wilis. (1996). *Teori-Teori Belajar*. Jakarta: Erlangga.
- Depdiknas. (2007). Buku Panduan Pengembangan Multimedia Pembelajaran. Jakarta: Direktorat Pembinaan Sekolah Mengah Atas. Departemen Pendidikan Nasional.
- Djamarah, Syaiful Bahri & Zain, Aswan. (2014). Strategi Belajar Mengajar. Jakarta: Rineka cipta.
- Dogan, Nihal & El Khalick, Abd Fouad. (2008). Turkish Grade 10 Student's and Science Teacher's Conceptions of Nature of Science : A National Study. Turkey : Department of Science Education. Abant Izzet Baysal University.
- Duschl, A. Richard., Schweingruber, A. Heidi., Shouse W. Andrew. (2007). Taking Science to School: Learning and Teaching Science in Grade K-8. Washington, DC: National Academic Press.
- Ferguson, Melanie., Brandreth, Marian., Brassington, William & Wharrad, Heather. (2015). Information Retention and Overload in First Time Hearing Aid Users: An Interactive Multimedia Educational Solution. United Kingdom: University of Nuttingham.
- Fitriana, Sari Ika. (2011). Penggunaan Multimedia Interaktif dalam Proses Pembelajaran Teori Kinetik Gas untuk Meningkatkan Pemahaman Konsep Siswa SMA. Jurnal Penelitian Pendidikan IPA, 5(1), 14-20.

- Gencer, Savran Ayse & Cakiroglu, Jale. (2005). Turkish Preservice Science Teacher's Efficacy Beliefs Regarding Science Teaching and Their Beliefs About Classroom Management. Turkey: Departement of Secondary Science and Mathematics Education. Faculty of Education. Pamukkale University.
- Glass, G.V. (1976). Primary Secondary and Meta Analysis of Research Review of Research in Education. Retrieved from: http://www.blackwellpublishing. com/medicine/bmj/systreviews/
- Hamalik, Oemar. (2011). Proses Belajar Mengajar. Jakarta: Bumi Aksara.
- Haryanto, I. Nyoman., Marhaeni, Anak Agung Istri Ngurah & Suarni, Ni Ketut. (2015). Pengaruh Model Pembelajaran Kooperatif Tipe STAD Berbantuan Video Animasi Terhadap Hasil Belajar IPA dan Kreativitas Siswa SMPLB C Negeri Denpasar. Indonesia: Program Pascasarjana Universitas Pendidikan Ganesha-Singaraja.
- Hill, Felix & Korhonen, Anna. (2014). Learning Abstract Concept Embeddings from Multimodal Data: Since You Probably Can't See What I Mean. United Kingdom: University of Cambridge.
- Huitt, W & Hummel, J. (2003). *Piaget's Theory of Cognitive Development*. Valdosta State University.
- International Energy Agency. 2012. *Annual Report*. Retrieved from: http://www.iea.org.
- Ivers, K & Baron, A. 2010. Multimedia Project in Education. USA.
- Jalali, Mohmmad Mojtaba., Masoumi, Ali., Farahani, Nodeh Milad., Hezaveh, Badkoobeh Vahid. (2015). Evaluating The Role of Digitl Media in The Quality of Training Learning Process of Students. Bachelor of Education Sciences, Farhangian University, Shahid Bahonar Campus of Arak.
- Johnsto, J.L & Moody, S.J. (2013). Motivation to Learn: Mattering From a Multicultural Perspective in School. *Journal Counseling International*, 5(1), 133-140.
- Kemdikbud. (2014). Materi Pelatihan Guru Implementasi Kurikulum 2013. Mata Pelajaran IPA SMP/MTs. Jakarta: Badan Pengembangan SDM Pendidikan dan Kebudayaan dan Penjaminan Mutu Pendidikan. Kementerian Pendidikan dan Kebudayaan.
- Koning, de B.B., Tabbers, Rikers RM & Paas, F. (2009). Attention Guidance in Lerning From a Complex Animation: Seeing is Understanding?. *Learning and Instruction*. 20(2). 111-122. Doi: 10.1016/j.learninstruc.2009.02.10.
- Koroghlanian, Carol & Klein, James D. (2000). The Use of Audio and Animation in Computer Based Instruction. Arizona State University.
- Krause, D.R., Handfield, R.B & Tyler, B.B. (2007). The Relationships Between Supplier Development, Commitment, Social Capital Accumulation and Performance Improvement. *Journal of Operations Management*, 3(2), 15-21.
- Liliasari & Tawil, Muh. (2014). Keterampilan-Keterampilan Sains dan Implementasinya dalam Pembelajaran IPA. Indonesia: Universitas Negeri

Makasar.

- Liu, X. (2006). Effects of Combined Hands-on Laboratory and Computer Modeling on Student Lerning of Gas Laws: A Quasi Experimental Study. Journal of Science Education and Technology. Springer.
- Magnesen, Vernon A. (1983). A review of Finding from Learning and Memory Retention Studies. Published by The National Institute For Staff and Organization Development With Support From The W.K. Kellogg Foundation.
- Mahfudz, Asep. (2012). *Cara Cerdas Mendidik yang Menyenagkan*. Bandung: Simbiosa Rekatama Media.
- Mayer, E. Richard. (2001). *Multimedia Learning*. New York: Cambridge University Press.
- -----. (2003). The Promise of Multimedia Learning: Using The Same Instructional Design Methods Across Different Media. Santa Barbara. USA: University of California.
- Merriyana A, Rosa. (2006). Meta Analisis Penelitian Alternatif Guru. Jurnal Pendidikan Penabur, 6(5), 18-22.
- Najjar, J. Lawrence. (1998). *Principles of Educational Multimedia User Interface Design.* Georgia: Institute Atlanta.
- Naor, Yamit Sharaabi., Kesner, Miri & Shwartz, Yael. (2014). Enhancing Student's Motivation to Learn Chemistry. Israel: Welzmann Institute of Science.
- National Research Council. (1996). *The National Science Education Standards*. Washington, DC. National Academy Press.
- Okoye, Okecha, Nnamdi S & Ebele, Rita. (2008). The Interaction of Logical Reasoning Ability and Socio-Economic Status on Achievement in Genetics Among Secondary School Student in Nigeria. College Student Journal.
- Organization for Economic Cooperation and Development. (2013). Snapshot of Performance in Mathematics, Reading and Science. Retrieved from: http://www.oecd.org/pisa/keyfindings/ PISA-2012-results-snapshot-volume I-Eng.Pdf)
- Pratiwi, Sarieny. (2011). Perbandingan Multimedia dengan Karakteristik yang Berbeda untuk Meningkatkan Penguasaan Konsep Siswa pada Materi Sistem pertahanan Tubuh. Jurnal Penelitian Pendidikan IPA, 5(1), 21-28.
- Pusat Kurikulum dan Perbukuan Balitbang. (2014).

Buku Guru IPA. Jakarta: Kemdikbud.

- Sardiman, A.M. (2014). *Interaksi dan Motivasi Belajar Mengajar*. Jakarta: Rajawali Press.
- Schrader, G. Peter & Eric, E. Rapp. (2015). Does Multimedia Theory Apply to All Students? The Impact of multimedia Presentations on Science Learning. Las Vegas. USA: University of Nevada.
- Shaffer, DR & Kipp, K. (2010). Developmental Psychology: Childhood and Adolesence. Belmont Wadsworth. Cengage Learning.
- Siagian, Sahat, Mursid & Wau, Yasaratodo. (2014). Development of Interactive Multimedia Learning in Learning Instructional Design. Educational Technology Pos Graduate. Indonesia: State University of Medan.
- Somantri, T Sutjihati. (2006). *Psikologi Anak Luar Biasa.* Bandung: Refika Aditama.
- Stoney, Sue & Oliver, Run. (1999). Can Higher Order Thinking and Cognitive Enggement be Enhanced With Multimedia? Edith Cowan University.
- Sungur, s & Tekkaya, C. (2001). The Effect of Gender Differences and Reasoning Ability on The Learning of Human Circulatory System Concepts. *Hacettepe University Egitim Fakultesi Dergisi*, 20(1), 126-130.
- Vieyra, Gustavo. (2006). A Dialectical Interpretation of Factual Knowledge in Vygotskyan Term Vs Bloom's Taxonomy as Interpreted by The Teaching Staff Elementary School. Los Angeles.
- Wang, Jing., Baucom, B. Laura & Shinkareva, Svetiana V. (2012). Decoding Abstract and Concrete Concept Representations Based on Single Trial FMRI Data. Columbia: Departement of Psychology, University of South Carolina.
- Wiyono, K. (2009). Penerapan Model Pembelajaran Multimedia Interaktif Untuk Meningkaatkan Penguasaan Konsep, Keterampilan Generik Sains dan Berpikir Kritis Siswa SMA Pada Topik Relativitas Khusus. Indonesia: Program Studi Pascasarjana UPI Bandung.
- Yusuf, L.N & H. Syamsu. (2008). *Psikologi Perkembangan Anak dan Remaja*. Bandung: Remaja Rosda Karya.
- Zahra, Binish Syeda. (2015). Effect of Visual 3D Animation in Education. Departement of Computer Science, Lahore Garrison University. *European Journal of Computer Science and Information Technology*, 3(1), 33-43.

JPII 5 (1) (2016) 83-93



Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# THE DEVELOPMENT OF GUIDED INQUIRY SCIENCE LEARNING MATERIALS TO IMPROVE SCIENCE LITERACY SKILL OF PROSPECTIVE MI TEACHERS

# M. I. S. Putra, W. Widodo, B. Jatmiko

Program Studi Pendidikan Sains, Pascasarjana Universitas Negeri Surabaya, Indonesia

DOI: 10.15294/jpii.v5i1.5794

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

## ABSTRACT

This study aimed to produce valid, practical and effective guided inquiry model science learning materials to enhance science literacy skill of prospective MI teachers. The tryout of the materials was implemented students of MI teacher education of Unipdu Jombang at academic year of 2015/2016 semesters 3 using One Group Pretest Posttest Design. The data collections were done using observation, testing, and questionnaires. Data were analysed using descriptive analysis of quantitative, qualitative and non-parametric statistical tests. The findings of the research were: 1) the learning materials were valid; 2) Practicality of the materials was tested through the implementation of lesson plans, while the learners' activity wereappropriate to the guided inquirymodel; and 3) The effectiveness of the learning materials in terms of improvement of learning outcomes of students was seen from the n-gain with high category and increasing mastery of science literacy skills of learners also scored n-gain with high category and the response of students to the device and the implementation of learning is very positive. It was concluded that the materials were valid, practical, and effective to enhance science literacy skills of prospective MI teachers.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: guided inquiry model, prospective MI teachers, science literacy, science learning materials.

## INTRODUCTION

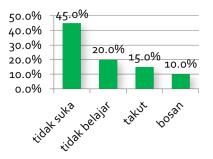
Natural science is the driving force of the development of information and communication technology that has fundamentally changed the human life. In the globalization era, many people's lives are affected by the development of science and technology. Many problems that arise in daily life require scientific information to solve it. Therefore, scientific literacy becomes a necessity for every individual to have a greater opportunity to adjust to the dynamics of life. As the time goes, information and technology keeps developing very rapidly. Everyone should be able to understand the environment, health, economic and other problems faced by modern society.

\*Alamat korespondensi: Email: mifta.unesa@gmail.com Therefore scientific literacy is a must for everyone. Scientific literacy is very important for a person because of the development level of a nation is determined by the quality of human resources that possess science and technology awareness (Genc, 2015; Jurecki, 2012; Holbrook, 2009; UNESCO, 2008; Turgut, 2007, 2005).Science education is expected to be able toimplant scientific literacy which in turn support Indonesia development. Science literacy has now become widespread concern for scientists, professors and politic's stakeholders (Impey, 2013).

Researches on science literacy skill of learners in an international scale are organized by the Organization for Economic Co-operation and Development (OECD) through the Programme for International Student Assessment (PISA). Scientific literacy is considered as a key in education for all students, whether or not to continue studying science after that (Turiman, et al., 2012; OECD, 2013).

The low scientific literacy level of Indonesia students is a solid proof that science learning in Indonesia still needs improvement. Interpretation can be inferred from the results of the PISA study that what we teach is different from the demands of the mankind. When we observed at the school, studentswere very good at memorizing, but less skilled in applying their knowledge in problem solving. It was probably associated with the tendency to use memorization as a mean for mastering science, not the ability to think. According to Toharuddin (2011), the science educators in Indonesia seemto not yet fully understand well about the learning that leads to conceptual abilities.

Development of scientific literacy of prospective teachers becomes the challenges of teaching and learning in higher education (Murcia, 2009). The results of the survey in 1988-2008 showed that the improvement of scientific literacy of students in American universities was less significant since it was only 10% -15% (Impey, 2013), while scientific literacy of prospective teachers in Turkey was also low (Akengin & Sirin, 2013).



**Figure 1.**Graphic of Preliminary of the Low Literacy of Prospective elementary teachers.

Results of a preliminary study conducted by researchers at 32 prospective MI (Islamic Elementary School) teachers at a private university in East Java showed a wide range of scientific literacy problems in science lectures. These problems included the heterogeneus educational background; dislikingscience (45%), unwillingness to study science(20%), fearing science(15%) and boring, negative perceptions of students towards science, their low interest in science (10%), resulting in inoptimal learning outcomes and low scientific literacy. These results show the existence of problems in science for prospective MI teachers, regarding with the process and learning outcomes of science. In general, it means that prospective MI teachers have not been able to achieve ideal characteristics of MI teacher, e.g. havingconsistent conceptual, procedural and epistemic knowledge to provide an explanation, evaluation, designingscientific discovery, and interpreting data on the diverse situations of complex life in which all requirehigh level cognitive thinking.

The development of literacy is needed to help prospective teachers to understand the materials and elements of science literacy, as well as being able to use appropriate teaching methods to develop scientific literacy in the classroom (Udompong et al., 2014). In improvingscientific literacy, prospective teachers should be given innovative learning so that the material being taught can be understood meaningfully for everyday life. Holubova (2013) states that all innovative learning methods should be learner-centered (active learning, Problem Based Learning, interdisciplinary relations) aims to improve the knowledge, concepts and skills of prospective teachers.

The science learning should equip prospective teachers with professional knowledge. Professional knowledge includes knowledge of content, pedagogical content knowledge, general pedagogical knowledge, and knowledge of learners and learning (Eggen & Kauchak, 2013). The learning environment and learning readiness also contribute to science learning achievement (Widyaningtyas et al., 2013). Lecturers must pay attention to teaching and learning that focuses on the right concept for students, strengthen their confidence, improving the relationship between the environment contexts with the teaching and learning (Udompong & Wongwanich, 2014). Activities with scientific methods are effective to develop scientific literacy and improve the learning process and success of learners (Toeman & Glucuer, 2012; Lederman, et al., 2013). Doing investigations in the laboratory can also increase scientific literacy and observation skills (Gormally, et al., 2012; Brickman, et al., 2009), and reading habits are elements that improve the scientific capabilities. Improving scientific skills reflect the increase of scientific literacy (Hamza & Ahmet, 2013). Literacy activities through scientific investigation or multiple learning modalities (read it, write it, do it, and talk it) provide support for teaching and learning science through inquiry (Odegaard et al., 2015).

One of the investigation activities in science learning at MI is by guided inquiry learning model. Guided inquiry learning model is an alternative to be developed to elevate science literacy. Guided inquiry learning modelconsists of six stages (phases): (a) planning, (b) information, (c) processing information, (d) making information, (e) communicating information, and (f) evaluating (Alberta, 2004). Guided inquiry learning allows learners to build knowledge independently and helps them to develop understanding of the concept of representative and exercises their scientific literacy (Pandey, et al., 2011; Stricklyn, 2011; Lee, et al., 2010; Minner, et al., 2010; Wilson, et al., 2010; David, 2006).

Based on the explanation above, the model of guided inquiry was selected to build science literacy of prospective MI teachers. Researchers designed and conducted research to develop teaching materials with guided inquiry model forimprovingscience literacy of MI teacher candidates. The focus of research concerned with the validity, practicality and effectiveness of the teaching materials with guided inquiry model to train scientific literacy skill of prospective MI teachers. The research aimed to produce valid, practical, and effective teaching materials with guided inquiry model to instill science literacy skill of prospective MI teachers.

#### **METHOD**

This study wasdeveloping science teaching materials with guided inquiry model to develop science literacy skill to prospective MI teachers. The research was carried during September to December 2015. Subjects were 35 learners of PGMI (MI Teacher Education) 3rd semester who took science subject in the academic year of 2015/2016.

The design of the research isOne–Group Pretest Postest design. (Fraenkel, 2012)

	Pre - test	Treatment	Post - test
	O1	Х	O2
Figur	e 2. One–G	roup Pretest	Postest design

The variables associated with this study are as follows:

- 1. Guided inquiry learning model
- 2. Validity of teaching materials
- 3. Variables related to the practicality of learning tools, including:
  - a. Learning implementation
  - b. Students' activity
- 4. Variables related to the effectiveness of learning tools, including:
  - a. Improvement of learning result
  - b. Science literacy skill
  - c. Students' response

#### **RESULT AND DISCUSSION**

Educators as innovative agents of change are required to have the ability to guide learners in the activities of scientific investigation (Lu, & Ortlieb, 2009; of Jan, et al., 2001). Educators in science learning ideally have to understand science conceptually and deeply, capable of reasoning qualitatively or quantitatively, able to understand and develop multiple representations, able to develop the skills of scientific literacy, having skill in science inquiry and be able to anticipate the conceptual difficulties experienced by learners (McDermott, et al., 2006; Heron, et al., 2005; Kautz, et al., 2005; and McDermott, 2004).

The learning model of guided inquiry is a learning model that fulfill many curriculum requirements through engagement, motivation, and learning challenging in line with the purpose for the 21st century for educational institutions to guide students to think and learn through inquiry (Madden, 2011; Kuhlthau, et al ., 2012; 2010; 2008; 2007).

Guided inquiry is characterized by identifying problems and some questions by educators as a research procedure and the learners are given clear and concise performance goal for investigation activities (Wenning, 2011; 2010; 2006; 2005). Application of guided inquiry learning does not only improve the ability of students to understand the material but can also enhance science process skills and scientific work (Ambarsari, et al., 2012; Ariesta & Supartono, 2011; Grant, 2011; Khan, et al., 2011).

Guided inquiry learning allows the learners to build knowledge independently and helps learners to develop understanding toward representative concept and develops scientific literacy (Pandey, et al., 2011; Stricklyn, 2011; Lee, et al., 2010; Minner, et al., 2010; Wilson, et al., 2010; David, 2006).

There are several characteristic of guided inquiry, they are:

- 1. Learners are conditioned to conduct investigations to gain knowledge.
- 2. Learners are encouraged to be active and reflected on the learning experience.
- 3. Students learn based on what they previously know.
- 4. Learners develop a range of thinking in the learning process through guidance.
- 5. The development of learners occur gradually.
- 6. Learners have different ways of learning.
- 7. Students are educated through social interaction with others.

(Ashiq, et al., 2011; Sadeh & Zion, 2011; Khulthau & Todd, 2008).

Guided inquiry learning offers integrated investigation planned and guided by educators, enabling learners to gain more understanding of the subject content of the curriculum and information concepts. Guided inquiry learning is able to develop the skills and abilities necessary for work and daily life in the 21<sup>st</sup>century (Gerald, 2011; Opara & Oguzor, 2011; Rust, 2011).

In brief, guided inquiry learning model has several advantages:

- 1. Increase learners' motivation.
- 2. Provide opportunities for learners to think further about ideas, problems, and questions.
- 3. Provide opportunities for learners to fully participate fully in the thing that will increase their curiosity, both inside and outside the classroom.
- 4. Encourage learners to have a initiative spirit.
- 5. Encourage patience, cooperation, unity, and decision-making between learners.
- 6. Improve students' understanding of the processes, concepts, and its relationships.
- Providing education and knowledge that allow them to explore the social environment. (NRC, 2011; Berg, *et al.*, 2003; Crawford,

2000; Crockett, 2000; Luft, 2001)

Guided inquiry learning model also has obstaclein which learners sometimes feel frustrated if they do not find the ideas (Belland, 2012; Krischner 2006; Fellenz, 2004). Guided inquiry learning model aims to give chance for learners to learn how to find the facts, concepts, and principles through direct experience, to improve science literacy and to train learners in investigating problems or questions.

Guided inquiry learning model is defined as an inquiry learning which presenting problems, questions and supporting material or materials specified by educators. Problems and questions from educators are meant to encourage students to conduct an investigation to determine the answer (Acevedo, et al., 2010; Bao, et al., 2009; Mercer, et al., 2004). Syntax guided inquiry learning has six phases (Alberta, 2004).

Guided inquiry learning model has a good and productive learning environment which the learners are actively trying to find and implement the processes of inquiry, and the role of educator is to guide learners inexperiment.

Management of guided inquiry learning is done in which students are grouped into several teams to be given the task of inquiry to conduct experiments and work well in a group, where educators will consistently guide the learning process undertaken by learners.

Summary data on the students' response to learning in the tryout can be seen in Table 2.

Table 1.Syntax guided inquiry learning

Phase	Explanation
1. Planning	Educator presents problems related to everyday life. Educators determine the procedure to solve the problem that will be done by students through experiments.
2. Retrieving	Learners find and collect data about the problems proposed educators from various sources.
3. Processing	Learners test and prove the hypothesis by conducting experiments and analysing his observations.
4. Creating	Learners make decisions and conclusions from his observations, then creating experiments reports.
5. Sharing	Learners present their observa- tions. Educators comment on the dis- cussions and provide reinforce- ment and straightenany mis- takes.
6. Evaluating	award each of the groups who have made presentations and then they provide authentic individual tasks regarding with the materials that have been studied.

(Source: Alberta, 2004)

## Table 2. Students' response

	Commo	Students	' response
No	Compo- nents	Average score	Criteria
1	Attention	4.20	Good
2	Relevance	3.80	Good
3	Confidence	4.00	Good
4	Satisfaction	3.95	Good

Table 2 states the response of students to guided inquiry learning is positive based on

86

Table 3. Science Literacy Skill Rubric

No	Science Literacy Skill	Level
1	Learners can describe and apply the inquiry inquiry scientific method in investiga- tion, questioning, and solving problems.	Beginner         a. Students cannot identify scientific problem.         b. Students do not understand the problem solving.         c. Students cannot identify hypothesis.         Middle         a. Students can identify scientific problem.         b. Students can identify scientific problem.         c. Students can identify scientific problem.         c. Students choose a solution for problem.         c. Students can define hypothesis.         Advanced         a. Students can repeat research questions.         b. Students can repeat research questions.
		<ul><li>b. Students can predict one or more solutions.</li><li>c. Students can construct hypothesis.</li><li>Expert</li></ul>
		<ul><li>a. Students can develop research questions.</li><li>b. Students can evaluate various alternative solutions.</li><li>c. Students can propose how to evaluate hypothesis correctly.</li></ul>
2	Learners can describe proce- dures and experiment steps	<ul> <li>Beginner</li> <li>a. Students cannot understand research purpose.</li> <li>b. Students cannot decide the materials for experiment.</li> <li>c. Students cannot interpret experiment variables.</li> <li>Middle</li> </ul>
		<ul><li>a. Students cannot rephrase the research purposes with their words.</li><li>b. Students can designate the materials for experiment.</li><li>c. Students can differentiate free and bound variables.</li><li>Advance</li></ul>
		<ul><li>a. Students can rephrase the research purposes with their words.</li><li>b. Students can designate the materials for experiment.</li><li>c. Students can differentiate control and free variables.</li><li>d. Students can explain the relation between steps in experiment.</li></ul>
		Expert
		<ul><li>a. Students can rephrase the research purposes with their words.</li><li>b. Students can designate the materials for experiment.</li><li>c. Students can filter free and control variables.</li><li>d. Students can manipulate free and control variables.</li><li>e. Students can modify the research design.</li></ul>

Table 3. Continue

No	Science Literacy Skill	Level
3	Students can present practicum assign-	Beginner
	ment correctly and accurately	a. Students cannot obey safety rules and use lab tools safely and carefully.
	acculately	b. Students cannot follow the writing procedure
		c. Students cannot identify scientific tools accurately
		d. Students cannot work independently.
		Middle
		a. Students obey safety rules and use lab tools safely and carefully.
		b. Students follow the writing procedure accurately.
		<ul><li>c. Students can use scientific tools with accurate techniques.</li><li>d. Students can measure and write the data.</li></ul>
		Advance
		a. Students obey safety rules and use lab tools safely and carefully.
		b. Students follow the writing procedure accurately
		c. Students can use scientific tools with accurate techniques.
		d. Students can measure and write the data with minimum mistakes.
		Expert
		a. Students take initiative to follow research procedures accurately.
		b. Students take initiative to follow writing procedures accurately.
		c. Students take initiative to use scientific tools with accurate
		techniques.
		d. Students take initiative to measure and write the data accurately.
	Students can in- terpret and com-	Beginner
	municate scientific information using	a. Students cannot interpret information quantitatively from the table and graphic using simple vocabularies.
	writing, verbal and graphic data.	Middle
	grupine dutu.	a. Students can interpret information quantitatively from the table and
		<ul><li>graphic using simple vocabularies.</li><li>b. Students can construct table data and present information in graph</li></ul>
		Advance
		a. Students can interpret information quantitatively from the table and
		graphic using simple vocabularies.
		b. Students can construct table data and present information in graph
		independently.
		c. Students can communicate experiment and investigation results.
		Expert
		a. Students can accurately interpret information quantitatively from the table and graphic using sophisticated diction, and make accurate to the table and graphic using sophisticated diction.
		inferences. b. Students can construct table data and present the information in
		graphic independently.
		c. Students csn communicate experiment and investigation results clearly.
		d. Students can draw logic conclusions based on the accumulated data

Table 3. Continue

No	Science Literacy Skill	Level
5	Learners can de- scribe and analyze one or more rela- tionship issues of science technology	<ul> <li>Beginner</li> <li>a. Students cannot identify technology breakthrough and its relationship with science.</li> <li>Middle</li> </ul>
	and society as well as demonstrating a scientific under- standing of the	<ul><li>a. Students can identify technology breakthrough and its relationship with science.</li><li>b. Students can put the technology breakthrough in historical context</li></ul>
	application in daily life.	<ul><li>c. Students can mention some effects of technology toward society.</li><li>Advance</li></ul>
		a. Students can identify technology breakthrough and its relationship with science.
		<ul><li>b. Students can put the technology breakthrough in historical context</li><li>c. Students can mention some effects of technology toward society.</li><li>d. Students can explain one or more scientific technology principals.</li></ul>
		Expert
		a. Students can identify technology breakthrough and its relationship with science.
		<ul> <li>b. Students can put the technology breakthrough in historical contex</li> <li>c. Students can mention some effects of technology toward society.</li> <li>d. Students can explain one or more scientific technology principals.</li> <li>e. Students can describe some examples or future development of scientific technology in society</li> </ul>
5	Learners can show the explanation of natural phenom- ena with a logical understanding, experiment steps or applying the con- cept of science and technology	Beginner
		a. Students can hardly identify logical explanation based on observation toward science phenomena.
		Middle
		a. Students can identify logical explanation based on observation toward science phenomena.
		b. Students can identify mindset error or illogical explanation based on observation.
		Advance
		<ul><li>a. Students can identify several alternative logical explanations based on observation toward science phenomena.</li><li>b. Students can identify mindset error or illogical explanation based</li></ul>
		on observation.
		Expert
		<ul><li>a. Students can identify several alternative logical explanations based on observation toward science phenomena.</li><li>b. Students can identify mindset error or illogical explanation based on observation.</li></ul>

c. Students can evaluate some statements based on observation, experiment, or accumulated data. (Adapted fromOECD, 2013; Gormally, 2012)

the average score of each of the conditions that support student learning interest with the criteria of very good. Likewise with the average score of each condition for student motivation is onvery good criteria.

Table 3 shows that there are 6 skills of scientific literacy which have multiple levels that have been developed by the researchers based on (OECD, 2013) that the skills of scientific literacy will be owned by a person in different levels after varied learning process depending on the previous understanding, the current understanding of the learning process and the ability of learners in associating their understanding with the concept or other situations.

Some of the findings in this study were based on results and strengthened byfacts during the learning. The findings in this study are as follows:

- 1. The validity of the developed learning tools can be seen from the results of the validity of the RPP, Student Worksheet, teaching materials, assessment instruments of students' learning outcomes (student attitude assessment instruments, testt instruments of knowledge aspect, the performance test instrument), and scientific literacy skill test instrument. The guided inquiry model of science learning for enhancing science literacy skill was declared valid.
- 2. Practicality of science teachingmaterials developed through the implementation in tryout 1can be seen from:
- a. The implementation of lesson plan in MI teacher educationsemester 3 Unipdu Jombang in the learning process with two replicates in overall average scored 3.70 categorized in good.
- b. Student activities at tryout stage were appropriate with guided inquiry model. In observations, the prominent activity were to design, conduct experiments, and analyse experimental results.
- 3. The effectiveness of the science materials through the implementation on trial I can be viewed from:
  - a. Application of the developed guided inquiry model of science materialcould improve students' learning outcomes: 1) the average n-gain of knowledge aspectof 0.88 belonged to high category, 2) the average n-gain ofscientific processingskill of 0.75 belonged to high category and the average n-gain of psychomotor skill of 0.82 belongedto high category and 3) achievement of attitude aspect reached good category.

- b. Implementation of the developedphysics learning materialswith guided inquiry model can improvescience literacy skill of prospective MI teachers. The increase of science literacy skills of prospective MI teachers could be seen from n-gain of the semester 3 obtained score of 0.85 with the high category.
- c. Students' responses were very positive toward the implementation of science learning with guided inquiry model. The analysis of students' response data were: Attention4.20, Relevance 3.80, Confidence 4.00, Satisfaction 3.95 and all belonged to good categorized.
- 4. The obstacles were: some students who had low academic plus low literacy skillsand students were still not yet familiar to guided inquiry learning model that mainly uses scientific processing skill and psychomotor in lab.

#### CONCLUSION

The results of this study indicated that the guided inquiry science learning materials were valid, practical, and effective to enhance science literacy skills of prospective MI teachers.

### REFERENCES

- Acevedo, N. A., Van Dooren, W., Clarebout, G., Elen, J., & Verschaffel, L. (2010). *Representational Flexibility in Linear Function Problems: A Choice / No-Choice study*. In L. Verschaffel, E. De Corte, T. de Jong and J. Elen (Eds.) Use or Representations in Reasoning and Problem Solving: Analysis And Improvement. Milton park, UK: Routledge, 74-93.
- Akengin, H & Sirin, A. (2013). A Comparative study upon determination of scientific literacy level of teacher candidates. *Academic journals, Vol.* 8(19), 1882-1886.
- Alberta, Learning. (2004). Focus on Inquiry: a teacher's guide to implementing inquiry based learning. Edmonton, AB: Alberta education.
- Ambarsari, Wiwin. (2012). Penerapan pembelajaran inkuiri terbimbing terhadap keterampilan proses sains dasar pad apelajaran biologi siswa kelas VIII SMP Negeri 7 Surakarta. Jurnal Pendidikan Biologi Univeristas Sebelas Maret.
- Ariesta, R. &Supartono. (2011). Pengembangan perangkat perkuliahan kegiatan laboratorium Fisika dasar II berbasis inkuiri terbimbing untuk meningkatkan kerja Ilmiah mahasiswa. Jurnal Pendidikan Fisika Indonesia (JPFI) Universitas Negeri Semarang. No. I Vol. 7 Halaman 62-68.
- Ashiq, H. A., Muhammad, A.& Azra, S. (2011). Physiscs Teaching Methods: Scientific Inquiry Vs Traditional Lecture. *International Journal of*

*Hummanities and Social Science*. Vol 1 No. 19; December 2011.

- Bao, L., Fang, K.&Cai, T. (2009). Learning of Content knowledge and development of scientific reasoning ability: A cross culture comparison. *American Journal of Physics*. 77 (12), 1118-1123.
- Belland, B.R., Walker, A., Olsen, W.&Leary, H. (2012). Impact of scaffolding characteristic and study quality on learner outcomes in STEM Education: a Meta-Analysis. Paper Presented at the (2012) AERA Annual Convention, Vancouver, British Columbia, Canada.
- Berg, C. A. R., Bergendahl, V. C. B.&Lundberg, B. K. S. (2003). Benefiting from an Open–Ended Experiment? A comparison of attitudes to, and outcomes of, an expository versus an open inquiry version of the same experiment.*International Journal of Science Education*, 25(3).
- Brickman, P., Gormally, C., Amstrong, N.& Hallar, B. (2009). Effects of inquiry-based learning on students' science literacy skills and confidence. *International Journal for the Scholarship of Teaching and Learning*, 3:2.
- Crawford, B. A., (2000). Embracing the essence of Inquiry: New Roles for science teachers. Journal of research in science teaching, 37 (9), 916-937.
- Crockett, M.D. (2002) Inquiry as Professional Development: Creating Dilemmas through Teachers work. Teaching and teacher education, 18, 609-624.
- David, M. H. (2006). Instructor's Guide To Process Oriented Guided Inquiry Learning. SUNY: Stony Brook University.
- Eggen, P.D. & Kauchak, D.P. (2013).*Educational psychology:* Windows on clasrooms (9<sup>th</sup> edition). New Jersey: Pearson.
- Fellenz, M. R. (2004). Using Assessment to Support Higher Level Learning: The Multiple Choice Item Development Assignment. Assessment and Education In Higher Education, 29(6), 703-719.
- Fraenkel, J. R., Wallen, N. E. & Hyun H. H.(2012). How To Design And Evaluate Research In Education, 8<sup>th</sup> Edition. New York : McGraw-Hill Companies, Inc
- Genc, Murrat. (2015). The Effect of Scientific Studies on Students' Scientific Literacy and Attitude. OMU Journal Fac. Educ. 2015, 34(1), 141-152.
- Gerald, F. L. (2011). The Twin Purposes of guided inquiry: guiding Student inquiy and evidence based practice. *Scan.* Vol 30 no 1 pp. 26-41.
- Gormally, C., Brickman, P. & Lutz, M. (2012).Developing a test of scientific literacy skills (TOSLS): Measuring Undergraduates' Evaluation of Scientific Information and Arguments.*Life Sciences Education*, 11, 364–377.
- Grant, H. (2011). The student experience intraditional and inquiry based chemstry labs. (PDF). Retrieved April 30, (2012) from Montana State University Library.
- Hamza, A. & Ahmet, S. (2013). A Comparative study upon determination of scientific literacy level

of teacher candidates. Academic journals. Educational Research and Riviews, 8:19, 1882-1886.

- Heron, P. R. L.&Meltzer, D. E. Guest Editorial. (2005). Future of Physics education Research: Intellectual Challenges and practical concerns. *American Journal of Physics*. 73 (5) 390-394.
- Holbrook, J.; Rannikmäe, M. (2009). The Meaning of Scientific Literacy. *International Journal of Envi*ronmental and Science Education, 4(3),275 - 288
- Holubova, R. (2013). Innovations in physics' teacher education – how to educate GEN Y teachers. Proceeding International Conference on Physics Education, August 5-9, 2013, Prague, Czech Republic. Pp. 459-465.
- Impey, C. (2013). Science literacy of undergraduates in the united states. Orgazations People and Strategies in Astronomy 2 (OPSA 2).Departement of Astronomy, University of Arizona.
- Jan, H., Van, D., Douwe, B.&Nico, V. (2001) Professionaldevelopment and reform in science education: the rule of teachers practical knowledge, Journal of research in science teaching. 38(2): 137-158.
- Jurecki, K. &Wander, M. C.V. (2012). Science Literacy, Critical Thinking, And Scientific Literature: Guidelines For Evaluating Scientific Literature In The Classroom. *Journal Of Geoscience Education, 60, 100–105*.
- Kautz, C. H., Heron, P.R.L., Loverude, M.E.&McDermott, L.C. (2005). Student understanding of the ideal gas law, Part I: a macroscopic perspective. *American Journal Physics*. 73(11) 1055-1063.
- Khan, M.S., Hussain, S., Ali, R., Majoka, M.I.& Ramzan, M. (2011). Effect of inquiry method on achievement of students in chemistry at secondary level.*International Journal of Academic Research*, 3(1): 955-959
- Kirschner, P. A., Sweller, J.&Clark, R.E., (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of The Failure of Constructivist, Discovery, Problem Based, Experiential, And Inquiry Based Teaching. *Educational Psychologist*, 41 (2), 75-86.
- Kuhlthau, C.C. (2007). *Guided Inquiry: Learning in the* 21th Century. USA: Center for International Sholarship in School Libraries (CISSL).
- Kuhlthau, C.C. (2010). Guided Inquiry. School Libraries Worldwide. Vol 16 No 1 January (2010) pp. 17-28.
- Kuhlthau, C.C.&Todd, R.J. (2008).Guided Inquiry. (Online).Tersedia www.icws.wikispaces.com/ file/view/Guided+Inquiry.doc.Diakses 5 Januari 2016.
- Kuhlthau, C.C., Maniotes, L.K.&Caspari, A.K. (2012).*Guided Inquiry Design*. Libraries Unlimited: Imprint ABC.
- Lederman, N.G., Lederman, J.S.&Antink, L. (2013) Nature of science and scientific inquiry as contexts for the learning of science and achievement of scientific literacy.*International Journal* of Education in Mathematics, Science and Technol-

ogy, 1:3, 138-147.

- Lee, H., Linn, M., Varma, K.&Liu, O. (2010) How to technology-enhanced inquiry science unit impact classroom learning? *Journal of Research in Science Teaching*.47, 71-90.
- Lu, L & Ortlieb, E.T. (2009) Teacher candidate as innovative change agents. *Current issues in education*, 11(5).
- Luft, J. (2001). Changing Inquiry Practices and beliefs: the impact of an inquiry-based professional development program on beginning and experienced secondary science teachers. *International Journal Of Science Education*, 23(5), 517-534.
- Madden, K.(2011). The Use Of Inquiry-Based Instruction To Increase Motivation And Academic Success In A High School Biology Classroom. (PDF). Retrieved April 30, (2012) from Montana State University Library.
- McDermott, L.C. (2004). *Physics by Inquiry* (online). Tersedia: htpp://www.phys.washington.edu/ RGroup/peg/pbi.html.
- McDermott, L.C., Heron, P.R.L., Shaffer, P.S.& Stetzer, M.P. (2006). Improving The preparation of K-12 Teachers Through Physics education research. *American Journal of Physics*. 74 (9) 763-767.
- Mercer, N., Dawes, L.&Wegerif, R., (2004) Reasoning as a scientist: ways of helping children to use language to learn science. *British Educational Re*search Journal. 30(3), 359-377
- Minner, D., Levy, A.&Century, J. (2010). Inquiry Based Science Instruction-what is it and does it matter? Results from a Research synthesis year 1984 to 2002. Journal of Research in Science Teaching, 47, 474-496.
- Murcia, K. (2009). Re-thinking the development of scientific literacy through a rope metaphor.Research *Science Education*, 39, 215–229.
- NRC (2011).*Inquiri and the national science education* standards.a guide for teaching and learning. Washington: National Academy Press.
- Odegaard, M., Haug, B., Mork, S. & Sorvik, G.O. (2015).Budding science and literacy.A classroom video study of the challenges and support in an integrated inquiry and literacy teaching model.*Procedia - Social and Behavioral Sciences*, 167, 274–278.
- OECD. (2013). PISA 2012 Results: Creative problem solving: Students' skills in tackling real-life problems (Volume V), PISA. Publishing: OECD.
- Opara, J.A.&Oguzor, N.S. (2011). Inquiry Instructional Method and the school science curriculum. Current Research Journal of Social Sciences. Vol 3 No.3 Summer (2011). Pp. 188-198.
- Pandey, G. K. Nanda&Ranjan, V. (2011).Effectiveness of inquiry training model over conventional teaching method on academic achievement of science student in India.*Journal of Innovative Research in Education*.1 (1), March, (2011). (pp.7-20).
- Rust, P. (2011). The effect of Inquiry Instruction on Problem Solving and Conceptual Knowledge

in a 9<sup>th</sup> Grade Physics Class.(PDF). Retrieved April 30, (2012) from Montana State University Library.

- Sadeh, I.& Zion, M. (2009). The Development Of Dynamic Inquiry Performance Within An Open Inquiry Setting: A Comparison To Guided Inquiry Setting. Journal of Research in Science Teaching. 46(10), 1137-1160.
- Stricklyn, J. (2011). What effect will using inquiry methods of teaching science have on 6<sup>th</sup> grade students?.Montana State University Library.
- Toeman, K. & Gucluer, E. (2012). The effect of using activities improving scientific literacy on students' acchievement in science and techplogy lesson. *International Online Journal of Primary Education, 1:1.*
- Toharuddin, U., Henrawati, S. & Rustaman, A. (2011). *Membangun literasi peserta didik*. Bandung: Humaniora.
- Turgut, H. (2005). The effect of constructivist design application on prospective science teachers' scientific literacy competence improvement at the dimensions of "nature of science "and" science-technology-society interaction". Unpublished *Doctoral Disertation*, Yıldız Üniversitesi, Sosyal Bilimler Enstitüsü: Instanbul.
- Turgut, H. (2007). Scientific literacy for all, *Journal of Faculty of EducationalSciences*, 40(2), 233-256.
- Turiman, P., Omar, J., Daud, A.M. & Osman, K. (2012).Fostering the 21st century skills through scientific literacy and science process skills. *Procedia - Social and Behavioral Sciences, 59, 110* – 116.
- Udompong, L. & Wongmanich, S. (2014). Diagnosis of the scientific literacy characteristics of primary students.*Procedia - Social and Behavioral Sciences*, 116, 5091 – 5096.
- Udompong, L., Traiwicitkhun, D. & Wongwanich, S. (2014). Causal model of research competency via scientific literacy of teacher and student. *Procedia-Sosial and Behavioral Science*, 116, 1581-1586
- UNESCO.(2008). Science education policy-making eleven emerging issues. UNESCO
- Wenning, C. J., (2005). Level of Inquiry: Hierarchies of Pedagogical Practices and Inquiry Processes. Journal of Physics Teacher Education.No.3 Vol. 2.
- Wenning, C. J., (2006). A framework for teaching the nature of science. Journal of Physics Teacher Education.3(3), March, pp.3-10.
- Wenning, C. J., (2010). Using Inquiry Spectrum learning to teach science. Journal of Physics Teacher Education Vol.5 No. 3 Summer pp. 11-17
- Wenning, C. J., (2011). Experimental Inquiry in Introductory Physics Course.JPTEO (Journal of Physics Teacher Education Online) Illionis State University Physics Department. USA. No. 2 Vol. 6.
- Widyaningtyas, A., Sukarmin & Radiyono, Y. (2013). Peran lingkungan belajar dan kesiapan belajar terhadap prestasi belajar fisika siswa kelas X

Sekolah Menengah Atas Negeri 1 Pati.*Jurnal Pendidikan Fisika, 1:1, 136-143.* 

Wilson, C.D., Taylor, J. A., Kowalski, S.M.& Carlson, J. (2010). The relative effects and equity

of inquiry based and commonplace science teaching on students knowledge, reasoning, and argumentation. *Journal of research in science teaching*, 47, 276-301.

JPII 5 (1) (2016) 94-100



Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# STEM LEARNING IN MATERIAL OF TEMPERATURE AND ITS CHANGE TO IMPROVE SCIENTIFIC LITERACY OF JUNIOR HIGH SCHOOL STUDENTS

# N. Khaeroningtyas<sup>1</sup>, A. Permanasari<sup>2</sup>, I. Hamidah<sup>3</sup>

<sup>1</sup>SMP N 1 Bumiayu, Jawa Tengah, Indonesia <sup>2, 3</sup>Universitas Pendidikan Indonesia, Bandung, Indonesia

#### DOI: 10.15294/jpii.v5i1.5797

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

#### ABSTRACT

This research aims to determine the improvement of students' scientific literacy after STEM (Science, Technology, Engineering, and Mathematics) learning using 6E Learning by DesignTM Model on temperature and its changes material. The research was conducted in SMP Negeri (State Junior High School) 1 Bumiayu in the academic year 2015/2016. The method used was quasi-experimental design with The Matching Only - pretest posttest control group design. This study used two group of experiment group of students who learned the material with STEM learning using 6E Learning by DesignTM, while the control group students learned with non-STEM learning. The analysis showed that the students' scientific literacy in experiment group is better than control group. The conclusion that can be drawn is STEM learning using 6E Learning by DesignTM on temperature and its changes material can improve students' scientific literacy.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: 6E Learning by DesignTM Model, Scientific Literac, STEM, Temperature and Its Changes.

# INTRODUCTION

Scientific literacy is an important thing to be mastered by students (Gucluer & Kesercioglu, 2012). This is because the individual achievement in science knowledge and skill implies on their readiness in the era of advanced technology use in the future (OECD, 2013). According to DeBoer (2000), scientific literacy term was first used in 1958 by Hurd, McCurdy and Rocklefeller Fund. Scientific literacy can be defined as an ability to understand the process of science and to engage with the available scientific information in daily life (Fives et al., 2014).

Science learning in Indonesia that leads to the formation of students' scientific literacy is still rarely to do. Most of the learning activity is still conducted conventionally and focus on stu-

\*Alamat korespondensi:

Email: nisakhaeroningtyas@yahoo.co.id

dents' conceptual mastery. One of them is shown by the data quality measurement of students' science learning outcomes internationally. Indonesian students' scientific literacy skill in science concepts included in low category in 2009, it was in the number of 57 of the 65 countries and in the number of 64 of 65 countries in 2012 (OECD, 2013).

The poor quality of students' science learning outcomes shows that the science learning process of schools in Indonesia is still ignoring the acquisition of students' scientific literacy (Toharudin et al., 2011). Therefore, the improvement of learning process of science that lead to the achievement of scientific literacy of students needs to be done to improve the quality of students' science learning outcomes.

One of the learning practices in Indonesia that can be developed is learning by integrating Science, Technology, Engineering, and Mathematics (STEM). National STEM Education Center (2014) in Firman (2015) stated that STEM learning does not only mean strengthening of practical education of STEM fields separately, but it is rather to develop an educational approach that integrates science, technology, engineering and math, by focusing on the educational process in daily life real solving. STEM education is able to form human resources' (HR) reasoning and thinking critically, logically, and systematically (Asmuniv, 2015). Learning through the integration of STEM can make students better prepared in the STEM field jobs (Brown et al., 2011), increase interest and achievement in mathematics and science (Stohlmann et al., 2012). OECD (2013) stated that an understanding of science and technology significantly contributes to the personal, social, professional and cultural lives of everyone.

STEM learning is related to the characteristics of science materials in junior high because some of them are closely related to technology, engineering and mathematics. Through STEM, learning process will be more meaningful so students' scientific literacy can be achieved.

The application of STEM learning can be done with various models (Carter, 2013), one of them is 6E Learning by Design<sup>™</sup> model. This learning model combines inquiry learning and design. 6E Learning by Design<sup>™</sup> model developed by the International Technology and Engineering Educators Association (ITEEA) by incorporating technology and engineering in learning process to become integrated STEM learning. Sanders (2009) in Burke & Barry (2014) stated that The ITEEA 6E Learning by Design<sup>™</sup> models provides a student centered framework for instruction that leverages the T and E of STEM as integrates content in a purposeful and informed way.

This study aims to determine the improvement of students' scientific literacy after STEM learning using 6E Learning by Design<sup>™</sup> on temperature and its changes material. Researchers chose temperature and its changes material because it is closely related to science, technology, engineering and mathematics in daily life.

#### **METHOD**

The method used in this study was quasiexperimental. In the experimental study, researchers give a different treatment between the two groups, and then study the effects of such treatment. The characteristic of quasi-experimental research is that researcher can not control all variables, except for some specific variables. The independent variable in this research is STEM learning using 6E Learning by Design<sup>™</sup> on temperature material, and the dependent variable is students' scientific literacy.

Subjects were divided into two groups, they are experimental group obtained STEM learning using 6E Learning by Design<sup>TM</sup> and control group obtained non-STEM learning.

The research design was Matching Only – Pretest Posttest Control Group Design. In this design, pretest was conducted in both groups. Measurement or observation was performed at the same time for both groups (Fraenkel et al., 2011). Diagram of the design can be seen in Figure 1.

Experiment group	М	0	Х	0		
Control group	Μ	0	С	0		
Figure 1. Matching Only – Pretest Posttest Con-						

trol Group Design Design

Both groups were pretest with instrument of test material that has been tested for its validity and reliability. Pretest is intended to determine the initial ability of both groups. Then those groups were given different treatment. To determine whether there is the effect of treatment, posttest was given to both groups.

Research was conducted in SMP Negeri 1 Bumiayu with population of seventh grade students in odd semester academic year 2015/2016. Samples are two classes of class VII E (experimental group) and class VII G (control group). Sample selection was done by random sampling class technique.

The research was conducted in three steps consisting of planning, implementation and final. In the planning steps, literature study on scientific literacy and STEM learning using 6E Learning by Design<sup>TM</sup> was done then instruments of scientific literacy test was prepared and validated the by four expert lecturers. The instrument trial was also conducted to students who have received the learning material of temperature and its changes, to obtain the validity and reliability of scientific literacy test instrument. Valid means the instrument can be used to measure what should be measured (Sugiyono, 2015). Data analysis technique is test instrument validity, reliability, difficulty level and discrimination power using Anates ver 4.0.9 application. In the implementation step, researchers conducted STEM learning using 6E Learning by Design<sup>TM</sup> in the experimental group and non-STEM learning in the control group.

In the final steps, the data were analyzed using SPSS 16 and reported. Before conducting

the research, students' initial was measure to ensure there was no difference of ability between the experimental and control group. Initial ability test data were taken from pretest of both groups then analyzed using SPSS 16 software.

Tests of Normality using Shapiro-Wilk test showed that the control and experimental groups were normalyl distributed (Sig. of control group =  $0.216 > \alpha = 0.05$  and Sig. of experimental group =  $0.153 > \alpha = 0.05$ ). Meanwhile Test of homogenity using Lavene test also showed that pretest data of both groups varied homogeneously (Sig. Based of Mean =  $0.475 > \alpha = 0.05$ ). Hypothesis testing of students' initial ability was done using Independent Samples Test. Sig test Independent Samples Test =  $0.388 > \alpha = 0.05$  (H<sub>0</sub> was accepted) so that it can be concluded there was no difference in the initial students' scientific literacy ability both of control and experimental groups.

To see the improvement of students' scientific literacy after applying STEM learning using 6E Learning by Design<sup>TM</sup> on temperature and its changes material, then hypotheses were formulated; null hypothesis ( $H_0$  = There is no significant difference of scientific literacy improvement between experimental and control group) and alternative hypothesis (Ha = There is significant difference of scientific literacy improvement between experimental and control group). To categorize the level of scientific literacy improvement, it used the data normalized gain (N-Gain). Interpretation (N-Gain) is (1) high = if  $g \ge 0.7$ ; (2) average = if  $0.7 > g \ge 0.3$ ; (3) low = if g < 0.3. (Hake, 1998).

#### **RESULT AND DISCUSSION**

STM learning on temperature and its chages material was divided into two parts, of STEM learning in temperature material and STEM learning in expansion material.

STEM learning using 6E learning by design<sup>TM</sup> on temperature material was conducted through six steps of learning. Step (1), Engage, aims to emerge students' interest so students would actively participate in learning process. In this step students paid attention to pictures and illustrations of story about the concept of tempe-

```
Kelompok: 1 (Genius)
```

#### JURNAL DESAIN ENGINEERING

#### Mendesain Pembuatan Skala Termometer

1. Identifikasi Pengetahuan yang dibutuhkan dalam desain Engineering :

Identifikasikan apa yang <b>telah</b> kalian ketahui!	Identifikasikan apa yang kalian <b>butuhkan</b> untuk diketahui!	Identifikasikan apa yang <b>ingin</b> kalian ketahui!
<ul> <li>Konsep partikel zat padat, zat cair, dan zat gas</li> <li>Energi panas (kalor)</li> <li>Bagaimana cara mengetahui suhu benda</li> <li>Pengertian tentang suhu.</li> <li>Cara menggunakan termometer dengan benar</li> <li>Prinsip kerja termometer</li> <li>Jenis - jenis termometer</li> <li>Pengertian titik tetap atas dan titik tetap bawah dalam penentuan skala suhu.</li> <li>Menghitung konversi skala suhu.</li> <li>Cara membuat skala suhu.</li> </ul>	<ul> <li>Pengertian tentang suhu</li> <li>Cara mengetahui suhu benda</li> <li>Cara menggunakan termometer dengan benar</li> <li>Prinsip kerja termometer</li> <li>Jenis - jenis termometer</li> <li>Titik tetap atas dan titik tetap bawah dalam penentuan skala suhu.</li> <li>Menghitung konversi skala suhu.</li> <li>Cara membuat skala suhu.</li> </ul>	<ul> <li>Pengertian tentang suhu</li> <li>Cara mengetahui suhu benda</li> <li>Cara menggunakan termometer dengan benar</li> <li>Prinsip kerja termometer</li> <li>Jenis - jenis termometer</li> <li>Titik tetap atas dan titik tetap bawah dalam penentuan skala suhu.</li> <li>Menghitung konversi skala suhu.</li> <li>Cara membuat skala suhu.</li> </ul>
Nilai – nilai kemanusiaan" yang	dapat kami peroleh dengan memu Səbər bertənggung jəu	pelajari materi suhu dan

Figure 2. Engineering Journal Design

rature shown by teacher, it was to explore memories of particles of matter concept. Furthermore, students used the engineering journal design to identify what they have already known, what they need to know and what they need. Students also identified problems of investigation of the and " the value of humanity" that can be obtained by studying temperature material (example of Engineering journal design is presented in Figure 2).

Step (2), Explore, aims to give students the opportunity to build their own understanding of the topics / materials. In this stage, student demonstrated an experiment to measure the temperature of water using sensory organs, then found out about the concept of thermometer and its types, making thermometer scale in Celsius thermometer, temperature scale conversion concepts from various sources, including the internet. In this case the teacher acted as facilitator by providing materials and guiding students to focus on learning. Students inquirí process was the guidance in exploration process. Stage (3), Explain, aims to give students the opportunity to clarify and improve on what they have learned and determined its meaning. Explain steps is where students communicate what they have learned. Stage (4), Engineer was in the fourth steps aimed to give students the opportunity to build a deeper understanding of material by applying the concept, practice and attitude. Students used the concepts that they have learned in the explore steps to design the thermometer scale manufacture.

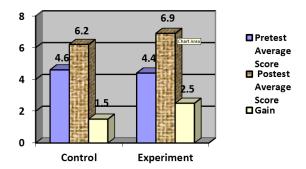
The next is step (5), Enrich, which aims to provide students the opportunity to explore more deeply about what they have learned and to transfer the concept into more complex problem. During this steps, students enriched the knowledge of adaptation mechanisms oof humans, animals and plants in maintaining stable body temperature.

The last step is (6) Evaluate where students and teacher determined how much learning and understanding they got. Students used selfevaluation sheet to assess the understanding of material. In addition, students assessed attitudes through self-assessment and peer assessment.

The improvement of students' scientific can be seen through the Gain value data formulated from score minus. The data is presented in Figure 3.

Figure 3 shows the improvement score of experimental group is higher than control group. To see whether after applying STEM learning using 6E Learning by Design<sup>TM</sup> model in temperature and its changes material would be different significantly with non-STEM learning, the data

pretest and posttest in both groups was analyzed using SPSS 16 with difference test of two independent samples. Before testing the hypotheses, normality and homogeneity test were performed. Normality test results based on the Shapiro-Wilk test showed the students' scientific literacy of control and experimental group were normally distributed because Sig. control group value =  $0.317 > \alpha = 0.05$  and Sig. experiment group value =  $0.255 > \alpha = 0.05$ . Homogeneity test using Levene showed that the data varied homogeneously because Sig. =  $0.728 > \alpha = 0.05$ .



**Figure 3.** Pretest and posttest score of students in temperature material

Both data were normally distributed and homogeneously varied then test of independent samples of t test was performed. Independent Samples Test The test results showed the value of Sig. (2-tailed) =  $0.003 < \alpha = 0.05$ . Therfore it can be interpreted that the null hypothesis is rejected, which means there is significant difference of students' scientific literacy improvement in control and the experimental group. Average score of students' scientific literacy in experimental and control groups is presented in Table 1.

**Table 1.** N- Gain Average and Classification of

 Students' scientific literacy

Group	N-Gain Average	Classification
Control	0,27	Low
Experiment	0,44	Moderate

The improvement of students' scientific literacy who obtained STEM learning using 6E Learning by Design<sup>TM</sup> Model in temperatures material was higher than non-STEM learning. Scientific literacy is in line with STEM literacy, for example understanding the concepts and procedural skills and ability of the individual to demonstrate STEM relation to the personal, social and global issues (Bybee, 2010). Students who obtained STEM learning will be more literate in STEM aspects, so students' scientific literacy will

automatically increase. This improvement also shows that the junior high school students can receive STEM learning, as well as Verma et al. (2011 that has successfully engaged students in STEM learning through 5E Learning Cycle.

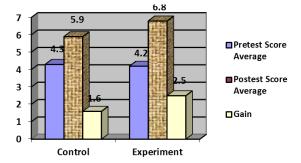
STEM learning using 6E Learning by Design<sup>™</sup> Model is basically a blend of inquiry and design. At explore step, students are guided by the Students' Worksheet (LKS) to find its own concept of material and designi experiments to solve the problems. The discovery of the concept through this inquiry is believed to make learning more meaningfully and to increase students' achievement in science. This is in line with McCright (2012) that stated the project-based inquiry learning can improve knowledge, principle and science process. Learning strategy by linking professional practice (STEM) is also meaningful strategies (Dierdorp et al., 2014).

The improvement of students' scientific literacy can be happened because they are more motivated to be able to design a thermometer scale and given the chance to access information via internet (technology). Gutherie et al. (2000) in his research concluded that by integrating STEM learning can increase students' motivation in learning. Moreover, in Engineer step it showed that students were more creative in designing the thermometer scale. In this step, students created their own thermometer by using simple tools. It is unexpected plan to design their own thermometer scale from non scale thermometer in the laboratory school. This is in line with Stohlmann Morrison et al. (2012) that stated there are some advantages in STEM learning, including making students to be better at solving problems, innovator, inventor, confident, thinking logically and literate in technology; it also can improve students' creative thinking skills (Oktavia, 2015). Engineering design beyond the planning made the researcher must be fast and responsive in designing learning process so it can be continued smoothly.

STEM learning in expansion material was done through the same steps with temperature material. In expansion material, students were asked to design an investigation to prove that a matter can expand. Students did the same design of designing the investigation of gas expansion in a balloon.

Students' scientific literacy of experimental and control groups is presented in Figure 4.

The score improvement of experimental group was higher than control group. Normality test results based on the Shapiro-Wilk test showed that scientific literacy data of control and experimental groups was because normally distributed control because Sig. control group =  $0.129 > \alpha = 0.05$  and experimentation Sig. experimental group value =  $0.092 > \alpha = 0.05$ . Homogeneity test using Levene test showed the data is not homogeneously varied because Sig. =  $0.041 < \alpha = 0.05$ .



**Figure 4.** Pretest and posttest score of students in expansion material

Both data were normally distributed but not homogeneously varied so the test was conducted by using independent samples t test by see the data in equal variance not assumed. Value Sig. (2-Tailed) =  $0.017 < \alpha = 0.05$  showed null hypothesis was rejected that implies there was a difference of students' scientific literacy improvement between control and experimental groups

Average score of students' scientfic literacy of control and experimental groups in expansion material is presented in Table 2.

**Table 2**. N- Gain Average and Classification of

 Students' scientific literacy

Group	N-Gain Average	Classification
Control	0,26	Low
Experiment	0,44	Moderate

Table 3. Research Result of Both Steps

Fase	Score Average	N-Gain Average	N-Gain Average	Category
1. STEM with 6E Learning by Design <sup>TM</sup> Model Temperature material	69	2,5	0,44	moderate
2. STEM with Model 6E Learning by Design <sup>TM</sup> Expansion material	68	2,55	0,44	moderate

The improvement of students' scientific literacy who obtained STEM learning using 6E Learning by Design<sup>™</sup> Model in expansion material was higher than non-STEM learning.

The data of research from both steps are presented in Table 3.

The improvenment of scientific literacy in both steps resulted the same result. However, if look further the second material is harder than the first, this indicates that students' scientific literacy can be built and increased if the learning process keeps training the thinking skills as required in the implementation of the 6E learning by design<sup>TM</sup> model based on STEM, In line with Becker & Park (2011) that stated learning by integrating STEM will bring positive impact on students' learning process.

#### CONCLUSION

STEM learning using 6E Learning by Design<sup>™</sup> Model in temperature and its changes can improve students' scientific literacy. The result indicates that scientific literacy can be improved if this model is applied continuously.

### **ACKNOWLEDGEMENTS**

We would like to thank to Ucapan terima kasih diberikan kepada Directorate general of Higher Education through the Chairman of The Institute for Community Research and Service In Semarang State University who funded through Decentralization Program of Competitive Grants.

#### REFERENCES

- Asmuniv. (2015). Pendekatan Terpadu Pendidikan STEM Upaya Mempersiapkan Sumber Daya Manusia Indonesia yang Memiliki Pengetahuan Interdisipliner dalam Menyongsong Kebutuhan Bidang Karir Pekerjaan Masyarakat Ekonomi Asean (MEA). Published on Friday, 15 Mei 2015.
- Becker, K & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education*, 12(6), 23-37.
- Brown R, Brown J, Reardon K & Merrill C. (2011). Understanding STEM: Current Perceptions. *The Technology And Engineering Teacher*, 70(6), 5-9.
- Burke, DTE & Barry N. (2014). 6E Learning byDesign<sup>™</sup> Model. The Technology And Engineering Teacher, 70(1), 14-19.
- ByBee, R.W. (2010). Advancing STEM education: A 2020 vision. *The Technology And Engineering*

Teacher, 70(1), 30-35.

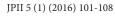
- Carter, Vinson R. (2013). Defining Characteristics of an Integrated STEM Curriculum in K-12 Education. (Disertasi). Arkansas: University of Arkansas. Retrieved from: ProQuest Digital Dissertations. (UMI Number: 3566045).
- DeBoer, GE. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, 37(6), 582-601.
- Diedrop A, Bakker A, Maanen, JAV & Eijkelhof, HMC . (2014). Meaningful Statistics in Professional Practices as a Bridge Between Mathematics and Science: An Evaluation of a Design Research Project. *International Journal of STEM Education*, 5(1), 1-9.
- Firman, Harry. (2015). Pendidikan Sains Berbasis STEM: Konsep, Pengembangan, dan Peranan Riset Pascasarjana. Seminar Nasional Pendidikan IPA dan PKLH, Universitas Pakuan Bogor, Indonesia.
- Fives H., Birnbaum, AS. & Nicholich M. (2014). Developing a Measure of Scientific Literacy for Middle School Student. Published online 18 June 2014 in wileyonlinelibrary.com.DOI.10.1002/ sce.21115.
- Fraenkel JR, Wallen NE & Hyun HH. (2012). *How to Design and Evaluate Research in Education*. United States: Mc Graw Hill.
- Gucluer, E & Kesercioglu, T. (2012). The Effect of Using Activities Improving Scientific Literacy on Students' Achievement in Science and Technology Lesson. *International Online Journal of Primary Education*, 1(1), 3-10.
- Gutherie, J.T., Wigfield A & VonSecker C. (2000). Effect of Integrated Instruction on Motivation and Strategy Use in Reading. *Journal of educational psychology*, *92*(1), 331-341, doi:10.1037/0022-0663.92.2.331.
- Hake, R.R. (1998). Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64-74.
- McCright, Aaron M. (2012). Enhancing Students' Scientific and Quantitative Literacies through an Inquiry-Based Learning Project on Climate Change. *Journal of the Scholarship of Teaching and Learning*, *12*(4), 86-102.
- Stohlmann M, Tamara J.M & Gillian H.R. (2012). Conciderations for Teaching Integrated STEM Education. Journal of Pre-College Engineering Education Research (J-PEER), 2(1), 22-29.
- OECD. (2013). PISA 2012: Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy. OECD Publishing. Retrieved from: http://dx.doi. org/10.1787/9789264190511-en.
- Oktavia, Rani. (2015). Penerapan Model Pembelajaran Model Proyek dengan Pendekatan Integrasi STEM dalam Meningkatkan Penguasaan Konsep dan Keterampilan Berpikir Kreatif Siswa SMP pada Materi

*Gelombang Bunyi.* Thesis. Bandung : Universitas Pendidikan Indonesia.

- Sugiyono. (2015). Metode Penelitian Pendidikan (Pendekatan Kuantitatif, Kualitatif dan R&D). Bandung: Alfabeta.
- Toharudin, U., Hendrawati, S., & Rustaman, A.

(2011). *Membangun Literasi Sains Peserta Didik*. Bandung: Humaniora

Verma, A. K, Dickerson, D., & McKinney, S. (2011). Engaging Student in STEM Careers with Project— Based Learning-MarineTech Project. The Technology And Engineering Teacher, 70(3), 19-26.





Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# IMPLEMENTATION OF SERIOUS GAMES INSPIRED BY BALURAN NATIONAL PARK TO IMPROVE STUDENTS' CRITICAL THINKING ABILITY

# P. D. A. Putra<sup>1</sup>, M. Iqbal<sup>2</sup>

<sup>1,2</sup> Universitas Jember, Indonesia

DOI: 10.15294/jpii.v5i1.5798

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

#### ABSTRACT

The purpose of this study is to implement Baluran National Park-based Serious Game to enhance the students' creative thinking skill and motivation to learn. The subject of the study were 60 students of SMP Negeri 1 Asembagus, Situbondo regency. The sample was divided into three groups. Two groups were chosen as experimental classes and the other group as the control class. Both of the experimental groups were given treatment using serious game based on Baluran National Park. The instruments used were observation sheet, pre-test, and post-test. Baluran National Parks-based serious game was effective in improving the students' creative thinking skill and motivation to learn science subjects.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: Baluran National Park, Creative Thinking Skill, Serious Game.

# INTRODUCTION

Upon entering the 21st century, there is a huge paradigm shift in the education process in Indonesia since there is an urgent need to balance our education quality toward international education level. One of the changes was the integration between the learning processes with digital service. The emergence of various types of learning technologies has encouraged educators, researchers, teachers and other practitioners to utilize this particular tool (Santally, 2005). Many believed that the use of digital media can improve student learning, increase student engagement and more effective management in learning (Perrotta, 2013). Forms of digital media include television, movies, games, music and internet (Padilla et al., 2012). Based on the aforementioned medias, the digital media which gives integrated factors of playing activities, challenges, and education is game. Nowadays, people are stimulated by the use of games for entertainment and

\*Alamat korespondensi: Email: pramudya.fkip@unej.ac.id playing facility (Girard et al., 2013). It was generally agreed that a very important reason why game have a positive effect on learning is because games provide live experience of user involvement (Cheng et al., 2015).

Game is an electronic media with the three key attributes that displays visual content, interactive, and entertainment. It also has various formats, applications and design. A digital game is divided into several types including traditional play (game watch), computer games, and webbased games (online) (Cheng et al., 2016). With main focus of educational purposes, a game will be called as a serious game to educate the players through pleasant experience (Chiu et al., 2015; Mortara et al., 2014). Serious game is a form of new topology designed for education and training (Arnab et al., 2015). There are five characteristics in games such as: (1) Game is freedom; (2) The game play has no risk in real life; (3) The location and time is different with real life; (4) Playing game needs something ideal; (5) Playing a game has nothing to do with the material or profits.

Based on the genre, serious game is divided into adventure, simulation, quiz, strategy, action and fighting games.

Dindar & Akbulut (2015) stated that the high anxiety level when playing games will reduce the motivation to use the game. While doing the research, it is necessary to review the serious game related with the genre and the cost so that the players feel comfortable in playing the game. For the convenience, the things need to be developed in a serious game is the dynamics and the environment. We assumed that the components (avatars, levels, unlocking content, leader boards, achievements, virtual view, point, team and badges) should be adapted to the environment and needs to be specified (Kocadere & Caglar, 2015).

Natural Science is a study that is based on the construction of knowledge through scientific activities and evaluation of empirical evidence (Decristan et al., 2015). It is more commonly known by the student that science has a symbol that represents an idea or concept (e.g. force, energy, chemical bonds) and has an analogy in the form of formulas, diagrams, graphics and simulations (Tang et al., 2014). In its development, science undergoes various changes in the teaching and learning process. Many kinds of methods had been proposed and applied to provide a good concept understanding for the students. Teachers and researchers had conducted mammoth experiments to teach science as effectively as possible. Many of those people had changed the teaching methods with the investigation, used a great deal of learning media, or even used the computer network such as the simulation to teach science. But various models are often polished with the overstatement of the effects on the students' learning process while ignoring social skills, emotional and motivational shifts (Rutten et al., 2012). For example, the use of games in learning does not do good in learning activities (Dobrowolski et al. ,, 2015; Shalom et al., 2015).

In the east part of Java island, there are three National Parks that provide rich forms of biodiversity. One of them is Baluran National Park, an area located in the border of Situbondo and Banyuwangi regencies, which inhabited by a lot of animals and plants endemic. Baluran National Park is often used as learning reference, especially in recognizing living and inanimate objects. This park is located in a very spacious area, divided into four major areas such as evergreen, savannah, mangroves and Bama beach becomes an obstacle in the learning process. To investigate the whole area will require a lot of time and expense, thus teachers often ignore the learning process based on the real world. Therefore, we need to develop a learning material in the form of Baluran National Park-based game to improve creative thinking skills and student motivation.

#### METHOD

The study was first started by selecting the control class and experimental class using cluster random sampling. The purpose of this study was to determine the impact of the use of Baluran National Park-based serious games on creative thinking skills of students and students' motivation. The main subject applied into the game is object classification and their biotic and abiotic environment. Sixty junior high school students participated in this research with an average age of 12.53 years (SD = 1.49 years). Experimental classes are divided into two groups: the first group was taught using Baluran National Parkbased game and was complemented with manual modules of Baluran National Park while the other experimental class was solely given the Baluran National Park-based game. The control class learned without the use of both serious game and manual modules.

The main instrument in this research is the serious games that had been developed based on Baluran National Park. To find out the data of students' motivation, a questionnaire was constructed using Likert scale with value of 1-5 (1 = disagree, 5 = strongly agree) depended on their choice. We also developed evaluation sheets for the pre-test and post-test that described the students' creative thinking skill level. Creative thinking skill indicators are developed by (Ku, 2015) in which it includes validity, flexibility, novelty and originality. Creativity is not just ideas, products and knowledge but also the involvement in the process of creative thinking. The instrument had been tested for 60 other students for the limited preliminary test. The reliability of instruments is shown in Table 1.

The serious game was developed based on the real ecosystem in Baluran National Park. There were 4 different levels as the miniature of the real things: evergreen, savannah, mangrove and Bama beach. Each level target could be completed by students after solving the existing problems. After the development process, the validity test was conducted by two experts in science and learning media. The results of the expert validation are shown in Table 2.

Prior to the learning activity, all participants took part in the pre-test for 50 minutes. Pretest was used to measure students' creative thin-

Table 1. Cronbach Alpha value of the instruments

Intrument	Number of question	Cronbach alpha	Description
Motivation	20	0.901	High
Validity	5	0.922	High
Flexibility	5	0.830	High
Novelty	5	0.730	Acceptable
Originality	5	0.780	Acceptable

Table 2 The expert validation of SGs

Aspect	Value	Criteria and Judgment
Display		
Layout		
Icon use	3.5	good
Image proportion	3.0	reasonable
Sound effect	3.5	good
Language	3.0	reasonable
Characters	3.0	reasonable
Contrast	3.0	reasonable
	3.0	reasonable
Content		
Contextual Problem		
Information	3.0	reasonable
Not causing misconceptions	4.0	good
Conformity of the story	3.5	good
	3.0	reasonable
Access		
Games format		
Facility	4.0	good
Network	3.5	good
	2.0	medium
Average value	3.21	Good

king skill before the treatment was given. Pre-test sheet contained questions about creative thinking skills and motivation to learn science. Learning was held for 3 weeks consisted of two meetings per week with the duration of 100 minutes. The topics taught were: differences in living and nonliving objects; solid, liquid and gas; elements and compounds. Each week the experimental classes were given the chance to play the serious game in the time span of 30 minutes. At the end of the activities, we carried out a post-test for 50 minutes.

## **RESULT AND DISCUSSION**

Before the implementation of the game based on Baluran National Park, the researchers first examined students' learning outcomes obtained in SMP Negeri 1 Asembagus. After that, we did field studies to copy the setting and to record various activities in Baluran National Park. The essence of this activity is to make the miniature version of the ecosystem as the game input.

Baluran National Park-based game is a side scrolling platform game with simple game play. Players need to take a particular item and avoid certain items, and they will go through four levels of Savannah, Evergreen, Beach, and Mangrove. Player will act as a Forest Ranger Hero who protects Baluran National Park plagued by Animal Treasure Hunter. At the end of each level, the player must beat the boss hunter to win the game. This game belongs to the "Serious Game: Game-based learning" which has the objective to provide knowledge and information through visualization within the game about animals, plants and abiotic environment in Baluran National Park. Additionally, the Banna game also provides a learning process to preserve Baluran National Park conservation area.

Figure 2 shows the display of games in Baluran National Park-based game. The interaction between users and game is through tap



a. Tampilan depan



c. rangger melewati musuh

b. Map Baluran



c. rangger, begal, akasia dan banteng

## Gambar 2. Example of the developed SGs

(Click). This makes the users play more comfortably compared to keyboard usage (Imbellone et al., 2015). Therefore, students can concentrate more on the educational content rather than thinking on how to use the game. After the module is declared valid (Table 2) by the validation experts, the game based on Baluran National Park is applied into the lesson. The results for the experimental class 1, experimental class 2 and control class can be viewed in Table 4.

Table 4 shows the results obtained in both learning using video games (experimental groups) and the control class. After the application of the games, most participants got a good value (M = 73.25 and 71.70). To be more specific, the post hoc test showed that learning by using video games resulted on better outcomes. To determine the effectiveness of the product, we carried out the effect size (ES) test and obtained a score of 0.67 with the average criteria. This proved that the use of video games based on the environment gave impact on student learning outcomes.

The motivation of the experimental classes' students was average with (M = 66.50 and 68.63). Since there were differences in learning outcomes between the experimental classes and

control class (psig < 0.05), we could do a further test using post hoc and found out that motivation of experimental classes' students was better than the control class. The use of game scored ES = 0.89 with high judgment value. Junior high school students were motivated by the use of environment-based games learning. This is in line with the character of the students at the beginning of formal operating conditions. Jackson et al. (2012) found that the use of games to 12 years old children causes a multi-dimensional relationship of creativity. Learning through games eases the students to understand the environmental development, think creatively and be active in improving the digital society (Navarrete, 2013). The continuous development of the digital environment around students made them responsive to their new environment. Based on Sun et al. (2015), there are three advantages of using games in learning; a means of entertainment, building motivation and developing collaboration attitude.

There were two hypotheses that had been tested in this study. The first is the effect of the use of environment-based game toward students' creative thinking skill. The game was proven effective in improving students' creative thinking

sing one way anno				
Pre-test mean	Post-test mean	SD	Sig	Posthoc
54.45	73.25	12.02	.035	1>3,2
52.67	71.70	8.21		
53.20	64.17	13.63		
40.62	66.50	7.36	.027	2>3,1
39.40	68.63	10.24		
40.12	61.18	8.35		
	Pre-test mean 54.45 52.67 53.20 40.62 39.40	Pre-test mean         Post-test mean           54.45         73.25           52.67         71.70           53.20         64.17           40.62         66.50           39.40         68.63	Pre-test mean         Post-test mean         SD           54.45         73.25         12.02           52.67         71.70         8.21           53.20         64.17         13.63           40.62         66.50         7.36           39.40         68.63         10.24	Pre-test mean         Post-test mean         SD         Sig           54.45         73.25         12.02         .035           52.67         71.70         8.21           53.20         64.17         13.63           40.62         66.50         7.36         .027           39.40         68.63         10.24

Table 4. Analysis result using one way annova

skill. This gaming media provided knowledge to students about the environment around the Baluran National Park. The students acquired the skill through observation, active interaction with the characters, performing repetitious experiments and interpreting the core part of the games associated with environmental effect in real life. This kind of game provides an interaction for players to learn how the avatars think about the environmental issues (Huang and Yeh, 2016). Therefore, in this game was divided into four different levels with varied avatars.

The use of Baluran National Park as the basis of the game had a significant impact in improving students' skill of creative thinking because most students of SMP N 1 Asembagus had visited Baluran National Park. Hawthorne et al., (2016) states that creativity test can be simulated in the real world. The state of the real world was made into a miniature in the form of role playing. Role playing allows individual to enrich creativity (Dyson et al., 2016). The ideal condition in the game enabled students to repeat the game against a failure. This repetition allowed students to plan better steps to pass certain level. This continuous experience caused students to be familiar with the game. The students did not solely pursue the completion of game, but they also devised a new strategy to be shared with others.

Through this game, the students owned the observation skill of the situation in Baluran National Park. They could even learn real experiences and generate real solutions through this game. Facing the environmental problem on the Baluran National Park that endangered the existence of biotic and abiotic environment, the students could suggest many solutions. For example, a student proposed to inhibit the rate of growth of acacia trees (acacia denticulosa) since it threatened the population of Java Bull (Bos javanicus). The achievement of flexibility indicators was done through the stages of the discovery of the facts, finding the problem and resolving problems. In this environment-based game, students were projected to think divergently resulting on several alternative answers. Lee & Therriault (2013) states that divergent thinking is a form of creative critical process, and it is a form of orientation of many solutions to solve problems. Some of students' solutions were then evaluated as discussions in learning activities.

The element of novelty is inherent in the process of creative thinking (Gillebaart et al., 2013). Unfortunately, students scored low in this department. Novelty indicators stressed on the ideas for solution to problems in Baluran National Park. Most students only justified the answers submitted by others. The good news was in the experimental class 1 where in addition to using video games, students were also guided by the instructions to play the game, they got a more structured answers in analyzing the problem. Students were able to combine all the instructions to be practiced on the game. This visual advantage made the students organize his knowledge. Martin & Schwartz (2014) has revealed that the use of visual media will help a lot in terms of creative thinking of students. In this class, the researchers obtained a more varied alternative answers. In addition, students were also able to evaluate the answers they found. Students then select the most effective response in protecting biotic and abiotic environment in the region of Baluran National Park.

Novelty and originality are interconnected indicators in creative thinking. This relationship is related to their breakthrough, uncommon, and practical idea (Yoon, et al., 2015). The target to reach 65% for these indicators was too difficult. The lacking in generating ideas was caused by students' unfamiliarity with the model of creative thinking skill training. Students mostly still tended to follow others. Students' independence in deciding a problem remained low. Evaluation to the serious game is the lack of verbal concepts explanation so that students did not know the important concepts implied in the game. Huang et al., (2013); Ulger, (2015) suggested that the visual and verbal material can be used as narrative and presentation to the development of creative thinking ability of students.

The game was developed to make the students happy and competitive in solving the existing problems. The adventure genre and the competition factor in play provided motivation for students to learn. Capturing real word setting impacted on the increased motivation for players (Kahn et al., 2015). Learning by using games instills emotional stimuli to the students to quickly accomplish tasks within the game. Design of each level in the game was created to trigger students to do the challenges. Giammarco et al. (2015) states that a game player's passion is to complete the challenge and go to the next level. Development of Environment-based game inspired by Baluran National Park had increased student's motivation to learn science especially in biotic and abiotic subjects.

Limitation of this study was the narrow scope of use. The selected sample was only a school near the Baluran National Park. It was suspected to influence the results since the student had already known almost everything about Baluran National Park. In addition there were students who had a high level of emotional anxiety that tended to disturb the motivation to learn. Further research needs to be conducted to determine the value of how much the level of anxiety in the learning process in using game influences the outcomes. Selection of larger samples is also necessary to give birth to a more reliable result.

#### **CONCLUSION**

There were different results (creative thinking skills and motivation to learn) for the experimental classes and the control class. The experimental classes showed higher creative thinking skill while using a environment-based serius game inspired by Baluran National Park. The use of Baluran National Park-based Serious Games scored 0.67 in effectiveness (medium) to the creative thinking skill of students. The students' motivation resulted of 0.89 in effectiveness (high) through the use of this serious game. The finding in this study suggested that students of SMP Negeri 1 Asembagus would be more optimal in learning when they were supplied with both Serious Games and a module that was oriented to the surrounding environment.

#### ACKNOWLEDGEMENTS

This research was supported by the Research Institute of Universitas Jember (Contract Number: 197/UN25.3.1/LT/2015). This research is competitive grants research funded by DP2M. We thank the SMP Negeri 1 Asembagus that has helped us in the data collection process.

#### REFERENCES

- Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., Freitas, S., Louchart, S., & De Gloria, A. (2015). Mapping learning and game mechanics for serious games analysis. *British Journal of Educational Technology*, 46(2), 391–411.
- Cheng, M.-T., Chen, J.-H., Chu, S.-J., & Chen, S.-Y. (2015). The use of serious games in science education: a review of selected empirical research from 2002 to 2013. *Journal of Computers in Education*, 2(3), 353–375.
- Cheng, M.-T., Lin, Y.-W., She, H.-C., & Kuo, P.-C. (2016). Is immersion of any value? Whether, and to what extent, game immersion experience during serious gaming affects science learning. *British Journal of Educational Technol*ogy. Retrieved from: http://doi.org/10.1111/ bjet.12386
- Chiu, P.-S., Wu, T.-T., Huang, Y.-M., & Ho, H.-L. (2015). The Effect of Peer's Progress on Learning Achievement in e-Learning: A Social Facilitation Perspective. In J. J. (Jong H. Park, Y. Pan, H.-C. Chao, & G. Yi (Eds.), Ubiquitous Computing Application and Wireless Sensor (pp. 537–542). Springer Netherlands. Retrieved from http://link.springer.com/chapter/10.1007/978-94-017-9618-7\_54
- Decristan, J., Hondrich, A. L., Büttner, G., Hertel, S., Klieme, E., Kunter, M., & Hardy, I. (2015). Impact of Additional Guidance in Science Education on Primary Students' Conceptual Understanding. *The Journal of Educational Research*, *108*(5), 358–370. Retrieved from: http://doi.or g/10.1080/00220671.2014.899957
- Dindar, M., & Akbulut, Y. (2015). Role of self-efficacy and social appearance anxiety on gaming motivations of MMOFPS players. *Computers & Education*, 81, 26–34. Retrieved from: http://doi. org/10.1016/j.compedu.2014.09.007
- Dobrowolski, P., Hanusz, K., Sobczyk, B., Skorko, M., & Wiatrow, A. (2015). Cognitive enhancement in video game players: The role of video game genre. *Computers in Human Behavior*, 44, 59–63. Retrieved from: http://doi.org/10.1016/j. chb.2014.11.051
- Dyson, S. B., Chang, Y.-L., Chen, H.-C., Hsiung, H.-Y., Tseng, C.-C., & Chang, J.-H. (2016). The effect of tabletop role-playing games on the creative potential and emotional creativity of Taiwanese college students. *Thinking Skills and Creativity*, 19(1), 88–96. Retrieved from: http://

doi.org/10.1016/j.tsc.2015.10.004

- Giammarco, E. A., Schneider, T. J., Carswell, J. J., & Knipe, W. S. (2015). Video game preferences and their relation to career interests. *Personality and Individual Differences*, 73 (1), 98–104.
- Gillebaart, M., Förster, J., Rotteveel, M., & Jehle, A. C. M. (2013). Unraveling Effects of Novelty on Creativity. *Creativity Research Journal*, 25(3), 280–285. Retrieved from: http://doi.org/10.10 80/10400419.2013.813781
- Girard, C., Ecalle, J., & Magnan, A. (2013). Serious games as new educational tools: how effective are they? A meta-analysis of recent studies. *Journal of Computer Assisted Learning*, 29 (3), 207–219. Retrieved from: http://doi.org/10.1111/j.1365-2729.2012.00489.x
- Hawthorne, G., Saggar, M., Quintin, E.-M., Bott, N., Keinitz, E., Liu, N., ... Reiss, A. L. (2016). Designing a Creativity Assessment Tool for the Twenty-First Century: Preliminary Results and Insights from Developing a Design-Thinking Based Assessment of Creative Capacity. In H. Plattner, C. Meinel, & L. Leifer (Eds.), *Design Thinking Research* (pp. 111–123). Springer International Publishing. Retrieved from http://link.springer.com/chapter/10.1007/978-3-319-19641-1\_8
- Huang, L.-Y., & Yeh, Y. (2016). Mediated enactive experience versus perceived mastery experience: An enhancing mechanism versus a mediator of character attachment and internal political efficacy in serious games. *Computers in Human Behavior*, 55, 1085–1096.
- Huang, P., Qiu, L., Shen, L., Zhang, Y., Song, Z., Qi, Z., Xie, P. (2013). Evidence for a left-over-right inhibitory mechanism during figural creative thinking in healthy nonartists. *Human Brain Mapping*, 34(10), 2724–2732.
- Imbellone, A., Botte, B., & Medaglia, C. M. (2015). Serious Games for Mobile Devices: the In-Touch Project Case Study. *International Journal* of Serious Games, 2(1). Retrieved from http:// journal.seriousgamessociety.org/index.php?jo urnal=IJSG&page=article&op=view&path%5 B%5D=41
- Jackson, L. A., Witt, E. A., Games, A. I., Fitzgerald, H. E., von Eye, A., & Zhao, Y. (2012). Information technology use and creativity: Findings from the Children and Technology Project. *Computers in Human Behavior*, 28(2), 370–376. Retrieved from: http://doi.org/10.1016/j. chb.2011.10.006
- Kahn, A. S., Shen, C., Lu, L., Ratan, R. A., Coary, S., Hou, J., ... Williams, D. (2015). The Trojan Player Typology: A cross-genre, cross-cultural, behaviorally validated scale of video game play motivations. *Computers in Human Behavior*, 49, 354–361.
- Kocadere, S. A., & Çağlar, Ş. (2015). The design and implementation of a gamified assessment. *Journal of E-Learning and Knowledge Society*, 11(3). Retrieved from http://je-lks.org/ojs/index.

php/Je-LKS\_EN/article/view/1070

- Ku, Y.-L. (2015). Evaluating creative thinking of RN-BSN students in the course of clinical case study and practicum. *Innovations in Education* and *Teaching International*, 52(3), 290–299. Retrieved from: http://doi.org/10.1080/147032 97.2013.838144
- Lee, C. S., & Therriault, D. J. (2013). The cognitive underpinnings of creative thought: A latent variable analysis exploring the roles of intelligence and working memory in three creative thinking processes. *Intelligence*, *41*(5), 306–320.
- Martin, L., & Schwartz, D. L. (2014). A pragmatic perspective on visual representation and creative thinking. *Visual Studies*, 29(1), 80–93. Retrieved from: http://doi.org/10.1080/147258 6X.2014.862997
- Mortara, M., Catalano, C. E., Bellotti, F., Fiucci, G., Houry-Panchetti, M., & Petridis, P. (2014). Learning cultural heritage by serious games. *Journal of Cultural Heritage*, 15(3), 318–325. Retrieved from: http://doi.org/10.1016/j.culher.2013.04.004
- Navarrete, C. C. (2013). Creative thinking in digital game design and development: A case study. *Computers & Education*, 69, 320–331. Retrieved from: http://doi.org/10.1016/j.compedu.2013.07.025
- Padilla-Walker, L. M., Coyne, S. M., Fraser, A. M., Dyer, W. J., & Yorgason, J. B. (2012). Parents and adolescents growing up in the digital age: Latent growth curve analysis of proactive media monitoring. *Journal of Adolescence*, 35(5), 1153–1165.
- Perrotta, C. (2013). Do school-level factors influence the educational benefits of digital technology? A critical analysis of teachers' perceptions. *British Journal of Educational Technology*, 44(2), 314– 327. Retrieved from: http://doi.org/10.1111/ j.1467-8535.2012.01304.x
- Rutten, N., van Joolingen, W. R., & van der Veen, J. T. (2012). The learning effects of computer simulations in science education. *Computers & Education*, 58(1), 136–153. Retrieved from: http:// doi.org/10.1016/j.compedu.2011.07.017
- Santally, M. (2005). From face-to-face classrooms to innovative computer-mediated pedagogies: Observations from the field. *Journal of Interactive Online Learning*, 3(4), 1–14.
- Shalom, J. G., Israeli, H., Markovitzky, O., & Lipsitz, J. D. (2015). Social anxiety and physiological arousal during computer mediated vs. face to face communication. *Computers in Human Behavior*, 44, 202–208. Retrieved from: http://doi. org/10.1016/j.chb.2014.11.056
- Sun, C.-T., Ye, S.-H., & Wang, Y.-J. (2015). Effects of commercial video games on cognitive elaboration of physical concepts. *Computers & Education*, 88, 169–181. Retrieved from: http://doi. org/10.1016/j.compedu.2015.05.002
- Tang, K., Delgado, C., & Moje, E. B. (2014). An Integrative Framework for the Analysis of Multiple

and Multimodal Representations for Meaning-Making in Science Education. *Science Education*, *98*(2), 305–326.

- Ulger, K. (2015). The Structure of Creative Thinking: Visual and Verbal Areas. *Creativity Research Journal*, *27*(1), 102–106. Retrieved from: http:// doi.org/10.1080/10400419.2015.992689
- Yoon, H., Woo, A. J., Treagust, D. F., & Chandrasegaran, A. L. (2015). Second-Year Col-

lege Students' Scientific Attitudes and Creative Thinking Ability: Influence of a Problem-Based Learning (PBL) Chemistry Laboratory Course. In M. Kahveci & M. Orgill (Eds.), *Affective Dimensions in Chemistry Education* (pp. 217–233). Springer Berlin Heidelberg. Retrieved from http://link.springer.com/chapter/10.1007/978-3-662-45085-7\_11





Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# THE INFLUENCE OF V DIAGRAM PROCEDURAL SCAFFOLDING IN GROUP INVESTIGATION TOWARDS STUDENTS WITH HIGH AND LOW PRIOR KNOWLEDGE

# R. Amelia, Supriyono Koes H., Muhardjito

Universitas Negeri Malang, Indonesia

DOI: 10.15294/jpii.v5i1.5799

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

# ABSTRACT

The learning achievement of high school students of Malang city in physics was still low, thus the appropriate learning strategies was necessaryto optimize the physics learning achievement. V diagram procedural scaffolding in Group Investigation was designed with the aim to optimize student learning achievement. The purpose of this study was to examine differences in learning achievement of groups of students who learn through Scaffolding Procedural strategies in Group Investigation and groups of students who are studying with Group Investigation, to examine differences in student achievement between thosewith high and low prior knowledge levels, and to examine the interaction between learning strategies (procedural scaffolding in GI and GI) and initial knowledge of students towardlearning achievement. The method used in this study wasquasi-experimental. The design used in this study was Two Factorial Design consisted of two experimental classes and two control classes each. The results indicated that learning achievement group of students who learn through proceduralscaffolding in Group Investigation. The learning achievements of students with high prior knowledge surpassed those with low prior knowledge. Last, there was an interaction between the learning strategies and prior knowledge of students toward learning achievement.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: Group Investigation, Learning Achievement, Prior Knowledge, Procedural Scaffolding, V Diagram.

# INTRODUCTION

The learning achievement is a major factor for the success of a lesson. The learning achievement is of paramount importance in determining the quality of students. However, academic achievement of senior high school students in Malang in physics was still low. This could be seen from the results of a national exam results which suggested that the average score of physics in Indonesia was not yet satisfactory. Average results of physics National Examination in Malang was lowest (Malang City 32, Malang regency 34, and Batu 38) among 38 cities and regencies in East Java (BSNP, 2013).

This wasprobably caused by teachers provide inappropriate learning related with students' prior knowledge in which some had high prior knowledge, but others were low. Students with higher prior knowledge tend to score higher than students whose prior knowledge initially low (Laili, 2014). Koes (2013) also reported that students with higher level of initial knowledge obtained a higher average physics score than those with low initial levels of knowledge. Students who hadsufficient prior knowledge would be able to follow the learning process well, causing them to get better learning results.

In a real class, students' prior knowledge varies greatly and making it difficult for teachers in implementing the learning activities. Variations of initial knowledge should serve as a guideline for giving lessons. As the result, a teacher might not be able to provide appropriate learning to each student with different initial knowledge because of the large number of students in the class. This obstacle can be overcomed by the provision of scaffolding.

Scaffolding is a way to facilitate various initial knowledge levels of students in the class. Puntambekar & Hubscher (2005) states that the scaffolding can help students to resolve complex problems, provide a structure for organizing scientific arguments and explanations, or further highlight the process of science. Scaffolding can also help teachers in the classroom which all groups cannot be monitored every time.

Procedural scaffolding is a relief that utilizes the available resources and tools (Yu et al., 2013). Procedural scaffolding isseries of procedural steps that must be passed and followed by the students. It also includes sequences that will be pursued in the search for a solution through experiments. Procedural scaffolding is used to guide students in doing experiments in the laboratory. Procedural scaffolding can improve their understanding of physics concepts (Laili, 2014) and the quality of student questions (Yu et al., 2013).

V diagram is one of the procedural scaffolding. V diagram helps students to link the concepts of science and designing investigations (Knaggs & Schneider, 2012), making learning more meaningful and effective, developing communication skill and scientific processing skills (Keles & Ozsoy, 2009). V diagram is an ideal tool to help students understand how a concept can be related to the others (Calals, 2009). V diagram can also develop students' knowledge in an organized and meaningful way (Tekes & Gonen, 2012).

V diagram can be applied in various learning, one of which is the cooperative learning. Jbeili (2012) suggests that the cooperative learning with scaffolding can improve conceptual understanding and procedural capabilities. O'Donnell et al. (2002) also added that students who use scaffolding on cooperative learning can learn more effectively. In cooperative learning, students will learn more effectively when they actively engaged in sharing ideas and working together to accomplish a task (Ebrahim, 2012). Pickles and Tarhan (2008) discovered that during the discussion during cooperative learning, students use their prior knowledge and experience, to think, to discuss, to share knowledge, and to apply the concepts acquired in a variety of other conditions.

One model in cooperative learning is the Group Investigation (GI). Group Investigation is a cooperative learning strategy in which students work in small groups to investigate a topic of learning (Kagan &Kagan, 2009). When the GI modelis applied in the classroom, the studentsare responsible for choosing their own topic of inquiry, problem formulation, planning and conducting investigations in various ways, and sharingtheir findings (Oh & Shin, 2005). Therefore, GI model can optimize students' achievement.

The study consisted of three focuses: (1) How is the learning achievement of a group of students who learn through Procedural Scaffolding strategy in Group Investigation compared to the group of students who are studying with only Group Investigation (2) How is the learning achievement of students who have a higher prior knowledge than group students who have a low level of prior knowledge (3) Is there any interactions between the learning strategies (procedural scaffolding in GI and pure GI) and initial knowledge of students toward student achievement.

# METHOD

The method used in this study is a quasiexperimental method (Quasi Experimental Design). The design of the study was Two Factorial Design consisted of the experimental group and the control group. The difference in treatment between the experimental class and control class laid in the applied model to both classes. The experiment class would useProcedural Scaffolding in Group Investigation, while the control class only applied Group Investigation model.

The study population was students ofscience classes XI of SMA N 3 Malang in academic year 2015/2016 who are divided in seven parallel classes. The sample in this study was taken using cluster sampling technique. This study used samples of 2 experimental classes and 2 control classes. Two classes of experimental were XI MIA 1 and XI MIA 2, while the two control classes were XI MIA 3 and XI MIA 4. The free variable in this research was the Procedural Scaffolding in Group Investigation and GroupInvestigation, while the dependent variable was the learning achievement. The moderator variable was the initial knowledge.

The instrument used in this study consisted of treatment instruments and measuring instruments. The treatment instrument is procedural scaffolding students worksheet Scaffolding in the form of Vdiagram. The measurement instruments were the initial knowledge tests and achievement tests.Initialknowledge test was used to determine students' prior knowledge before the experiment, thus we achieved data showed groups of students with low initial knowledge and groups of students with high prior knowledge. In this study, we recorded students' initial knowledge of physics in vectors, Newton's law, energy and effort. The achievement test was material dynamics of rotation in multiple choice format. Before applied, the entire instrumentswere validated by two expert lecturers and the questions were tried out.

Test analysis consisted of normality and homogeneity tests. The analysis was performed using SPSS 16.0 for Windows with Kolmogorov-Smirnovmethod. Homogeneity test was performed using Levene test through One WayAnova. Afterthe premilinary analysis was completedand the target was met, then the hypothesis was tested using by two lanesAnova. Hypothesis test was to test the differences in student achievement after studied using Procedural Scaffolding on GI and pure GI, as well as to see the interaction between the learning using Procedural Scaffolding on GI and prior knowledge on student achievement.

# **RESULT AND DISCUSSION**

#### Description of Prior Knowledge Data

The initial knowledge test was given to 59 students of experimental class and 62 students of control class. Data from this test wasthen sorted from the biggest score to the smallest one. Furthermore, the initial knowledge test result data were grouped into high initial knowledge and low prior knowledge groups. Grouping of initial knowledge based on the combined average score of all classes resulted of 13.04. Based on the classification, 74 students had high prior knowledge and those with low prior knowledge amounted for 47 students. The number represented the combined students of experimental classes and control classes. In experimental classes, there were 33 students with high prior knowledge and 26 students with low prior knowledge. While there were 35 high prior knowledge students and 27 students with low prior knowledge in control classes. The statistic of prior knowledge data can be seen in Table 1.

Based on Table 1, the initial knowledge score in the experimental class with 59 respondents had a minimum score of 6.00, maximum score of 25.00, average score of 13.28, and a standard deviation of 3.73. Prior knowledge on the control

class with 62 students obtained a minimum score of 6.00, maximum score of 22.00, average score of 12.81, and a standard deviation of 3.54. Based on the table, we could conclude that the average prior knowledge score in the experimental class at 13.28 was higher than the average score of prior knowledge in control class at 12.81.

Description of the initial knowledge data of experimental classes and control classes grouped into high prior knowledge and low prior knowledgewere summarized in Table 2.

According to table 2, the high prior knowledge students in experimental classes high with the amount of 33 students hadminimum score of 13.00, maximum score is 25.00, average score of 15.54, and standard deviation score of 3, 39. While 26 low prior knowledge students in experimental classes serve of 12.00, average score of 6.00, maximum score of 12.00, average score of 10.42, and standard deviation score of 1.53.

35 students with high prior knowledge in control classesachievedminimum score of 13.00, maximum score of 22.00, average score of 15.08, and standard deviation score of 2.67. While as many as 27 students with low prior knowledge in control classesgot minimum score of 6.00, maximum score of 12.00, average score of 9.85, and standard deviation score of 2.03.

Based on Table 2 can be explained that the average score of high prior knowledge in experimental classes 15.54 wasbetter than the high initial knowledge students in control classes at 15.08. In addition, the average score of low initial knowledge in the experimental classes at 10.42 wasalso better than those on control class at 9.85.

# **Description of Learning Achievement Data**

The data were obtained from learning achievement instruments in the form of 16 multiple choice questions with the material of the rotational dynamics and rigid body equilibrium. Learning achievement test was conducted after the treatment completed. This test was conducted for 75 minutes. The description of learning achievement data in the experimental classes and control classescould be seen in Table 3.

Based on Table 3, the learning achievement of 59 students in experimental classesproduced minimum score of 8.00, maximum score of 15.00, average score of 10.36, and standard

 Table 1. Statistical Description of Prior Knowledge Data

	Ν	Minimum	Maximum	Mean	Std. Deviation
Experimental classes	59	6.00	25.00	13.2881	3.73266
Control classes	62	6.00	22.00	12.8065	3.54752

	N	Minimum	Maximum	Mean	Std. Deviation
High prior knowledge experimental classes	33	13.00	25.00	15.5455	3.39200
Low prior knowledge experimental classes	26	6.00	12.00	10.4231	1.52769
High prior knowledge experimental classes	35	13.00	22.00	15.0857	2.67198
High prior knowledge experimental classes	27	6.00	12.00	9.8519	2.03250

**Table 2.** Statistical Description of Students with High Prior Knowledge and Low Prior Knowledge

Table 3 Statistical Description of Learning Achievement in Experimental and Control Classes

	Ν	Minimum	Maximum	Mean	Std. Deviation
Experimental classes	59	8.00	15.00	10.3559	1.71969
Control classes	62	6.00	13.00	9.7581	1.93912

**Table 4** Statistical Description of Learning Achievement Data of High and Low Prior Knowledge in

 both Experimental and Control Classes

	Ν	Minimum	Maximum	Mean	Std. Devia- tion
High prior knowledge experimental classes	39	8.00	15.00	10.4615	1.86161
Low prior knowledge experimental classes	20	8.00	12.00	10.1500	1.42441
High prior knowledge control classes	35	8.00	13.00	10.8000	1.38903
Low prior knowledge control classes	27	6.00	12.00	8.4074	1.71552

deviation of 1.72. Meanwhile, the learning achievement of 62 students in control classes obtained minimum score of 6.00, maximum score of 13.00, average score of 9.76, and a standard deviation of 1.93. Based on the table it can be explained that the average score of the learning achievement in the experimental class at 10.36 is higher than the average score of the learning achievement in the control class at 9.76.

Description of achievement data of both classes grouped into high prior knowledge and low prior knowledge were listed in Table 4.

In table 4, we can observe the learning achievement of 39 students with high prior knowledge in experimental classes gained minimum score of 8.00, maximum score of 15.00, average score of 10.46, and standard deviation score of 1.86, while learning achievement of 20 low prior knowledge students in experimental classesreceived minimum score of 8.00, maximum score of 12.00, average score of 10.15, and standard deviation score of 1.42.

The learning achievement of 35 students with high prior knowledge in control classes gained minimum score of 8.00, maximum score of 13.00, average score of 10.80, and standard deviation score of 1.39, while learning achievement of 27 low prior knowledge students in control classesreceived minimum score of 6.00, maximum score of 12.00, average score of 8.41, and standard deviation score of 1.72.

The average learning achievement score of students with high initial knowledge in the experimental classes 10.46 was higher than those in the control class at 10.80. Also, the average learning achievement score of students with low initial knowledge of the experimental classat 10.15 was higher than those in control classes 8.41.

# Normality and Homogeneity Tests

Based on the test of normality using Kolmogorov - Smirnov on learning achievement scores, the experimental classes learning achievement scores were normally distributed with significance of 0.233 > 0.05 and the control classes learning achievement scores were also normally distributed with significance of 0.352 > 0.05. Based on the analysis the researchers concluded that the distribution of learning achievement data in both experimentaland control classes were normally distributed and metthe intended requirements.

112

Based on homogeneity test using Levene's test, thelearning achievement in the experimental and control classes were homogeneous with significance of 0.26 > 0.05. Based on the results of this analysis the test prerequisites were met.

# First Hypothesis Test Result

Two line ANOVA analysis resulted on  $F_{count}$  of 5,228 with a value of 0,024 < 0.05. It can be concluded that the null hypothesis (Ho) was rejected, meaning that the learning achievement of groups of students who learned using Procedural Scaffolding in Group Investigation were different with a group of students studying with only Group Investigation. The average scores of learning achievement of groups of students who learned through the Scaffolding Procedural with Group Investigation at10.36 was higher than the group of students studying with Group Investigation at 9.76.

Learning usingV diagram procedural scaffoldingprovided an opportunity for students to have discussion. Formation of each group of students with heterogeneous prior knowledge could help the interaction between friends in a group. Students with high prior knowledge could assist students with low prior knowledge. The interraction could facilitate students to build knowledge together, so they could get higher learning achievement.

The interaction occured in a class could help students in improving learning achievement. Fatokun & Omenesa (2015) states that classroom interaction can increase students' interest andmaterial understandingleading to higher learning achievement. In addition, teachers also need to connect students' initial knowledge with the learning process to help students to understand science concepts.

V diagram procedural scaffolding strategies in GI brought positive impact on learning achievement. That was because this strategy provided an excellent mean for students to engage fully in dialogue to solve the problem with high success rate. This engagement clearly supported the increase in student achievement.

The results of classroom observations on learning using procedural scaffolding in GI showed that students could explain the relevance within practicum and the material to be studied. Based on the results, students were able to explain some of the related material. Moreover, students could develop the results obtained. In addition, during the learning process students' curiosity in procedural scaffolding V diagram in GI was very visible since students often asked the about the materials rather than the procedures during practicum.

Students who solely studied using Group Investigation could only explain the achieved data afterpracticum. Studentscouldnot develop the research result. They also did not have high curiosity because when the teacher gave reinforcement material, students simply observed and recorded without any question.

This research was supported by the findings of Cagiltay (2006) who found that the procedural scaffolding supports the design and develops self-learning activities. Yu et al. (2013) found that the use of procedural scaffolding supports students in learning activities. The results of students who use procedural scaffolding are better than students without using scaffolding-procedural (Yu et al., 2013). Hsu et al. (2014) revealed that the scaffolding greatly assists the process of investigation and the developmentof understanding toward a concept.

# **Results of Second Hypothesis Tests**

Test results obtained from analysis of two lanes variance  $F_{count}$  was 19.39 with significance of 0.00 < 0.05. It can be concluded that the null hypothesis (H<sub>o</sub>) was rejected, meaning that the learning achievements of students with high of prior knowledge were different from those with low prior knowledge. From the average score of all students, it could be concluded that the average score of students' learning achievement with high prior knowledge at 10.62 was higher than the group of students studying with Group Investigation at 9.15.

The results of observations in the classroom displayed that the students with high initial knowledge showed tendency to dominate the class. The students seemed to pay serious attention to the learning process and askedanything they had not yet understood. When teachers askedthem tosolve the problems, students with high prior knowledge gave direct response and did the tasks.

High prior knowledge students often askedmore complex questions. This was in line with Taboada & Guthrie (2006) that students' questionsare positively associated with reading ability. Students with high initial knowledge in particular domain tended to have a better question proportion or higher level questions than those with low prior knowledge.

Prior knowledge is a prerequisite to learn new knowledge. The more relevant the prior knowledge of the students, it wouldease them to learn new things. Prior knowledge is a prerequisite occurrence of meaningful learning. Initial knowledge can serve as a foundation of learning that can help students' understand a concept.

High initial knowledge students wouldfind it easy to transfer the knowledge they possessed to receive new knowledge and applied the physics concepts in a problem that required some variation and suggested new things. Low initial knowledge students still had difficulty to suggest some variation and novelty related to the concept of physics. Thompson & Zamboanga (2004) stated that prior knowledge affects students in accepting new knowledge. Pror knowledge influences a person's response whenfacing new situations and contributing to learning of new knowledge.

Ionas et.al. (2012) states that when students have an understanding of separated concepts, when trying to accept new information, they do not pay attention to the relationships between concepts, thus students understand the new concepts separately and are not able to connect between concepts. Therefore, in case of learning new knowledge, students should look for the circumstances, concepts or processes in theirmind to construct new knowledge or to solve new problems.

Seery (2009) states that the initial knowledge has a strong influence on student performance. It essentially constructsstudents' frame of mind. In addition, students with high initial knowledge will have the better confidence and tend to have a positive attitude. Ionas et.al. (2012) stated that prior knowledge impacts on the effectiveness of self-explanation in solving chemistry problem. The higherthe initial chemical knowledge, the strongerhis self-explanation will get. Meanwhile, students with low initial knowledge will experience difficulty in doing self-explanation.

# Third Hypothesis Test Results

The analysis of two lanes variance test resulted on  $F_{count}$  of 11.48 with significance of 0.001 < 0.05. It could be concluded that the null hypothesis (H<sub>a</sub>) was rejected, meaning that there was an interaction between the learning strategies and students' prior knowledge to the learning achievement. This might occur because the V diagram procedural scaffolding provides the opportunities for students to understand and solve the problemsby themselves. All students were given equal chances to be actively involved in the learning process, to take part ininvestigating subtopics, and discussions. In discussion, students of both high and low prior knowledges help each other to construct new knowledge together. This optimal involvement caused the V diagram procedural

scaffolding strategy in GI could influence on student learning achievement of physics.

Observation results showed that in the learning usingV diagram procedural scaffolding in GI, students withhigh prior knowledgeable were faster in investigating sub topic by following the scaffolding listed on the students' worksheet those with low prior knowledge, thus it enabled them to help others in their groups. In addition, students with low initial knowledge solved the problems with the help of high prior knowledgestudents. That is why,students with high prior knowledge indirectly increased students with low prior knowledge's physics learning achievement. This ultimately caused the difference in learning achievement among students with high and low initial knowledge.

These results are consistent with a study by Reisslein et al. (2007) who found that there isinteraction between prior knowledge and learning strategies.Reisslein also stated that the engineering students with high prior knowledge on basic electrical circuits showed better learning achievement in problem solving tasks than students with low initial knowledge.

# **CONCLUSION**

Based on the general description, hypothesis testings, and discussion the researcherscouldput forward three research conclusions as follows: (1) The learning achievement of groups of students who learn through Procedural Scaffolding strategies in Group Investigation was higher than the group of students studying with Group Investigation. This wasevidencedby the test results obtained from two lanes Anova with  $F_{count}$  of 5,228 with significance of 0,024 < 0.05. (2) The learning achievement of students with high initial knowledge was higher than those with low prior knowledge. This was proven from the test results obtained with two lanes Anova with  $\mathrm{F}_{\mathrm{count}}$  of 19.39 with significance of 0.00 < 0.05. (3) There was interaction between the learning strategies and prior knowledge toward learning achievement. This wasshowed from the analysis of test results by two lanes Anovawith F<sub>count</sub> of 11.48 with significance of 0.001 < 0.05.

#### REFERENCES

- Acar, B. & Tarhan, L. (2008). Effects of Cooperative Learning on Student's Understanding of Metallic Bonding. *Springer. Res Sci Edu.*, 38 (1), 401-420.
- BSNP. (2013). Laporan Hasil Ujian Nasional Tahun Pelajaran 2011-2012. Jakarta: Balitbang
- Cagiltay, K. (2006). Scaffolding Strategies in Electronic

Performance Support Systems: types and challenges. *Innovations in Education and Teaching International*, 43(1), 93-103.

- Calals, G.J. (2009). The Vee Diagram As a Problem Solving Strategy: Content Area Reading / Writing Implications. National Forum Teacher Education Journal, 19 (3), 15-23.
- Ebrahim, A. (2012). The Effect of Cooperative Learning Strategies on Elementary Students' Science Achievement and Social Skills in Kuwait. *International Journal of Science and Mathematic Education*, 10 (1), 293-314.
- Fatokun & Omenesa. (2015). Effect of Prior Knowledge and Classroom Interactions on Student's Achievement in Chemistry. *African Educational Research Journal*, 3(3), 184-189.
- Hsu, Y.S., Lai, T.L. & Hsu, W.H. (2014). A Design Model of Distributed Scaffolding Inquiry Based Learning. *Res Sci Educ.* 1 (2), 23-30.
- Ionas, I.G., Cernusa, & Harvest L.C. (2012). Prior Knowledge Influence on Self-Explanation Effectiveness When Solving Problems: An Exploratory Study in Science Learning. *International Journal of Teaching and Learning in Higher Education*, 24(3), 349-358.
- Jbeili, I. (2012). The Effect of Cooperative Learning with Metacognitive Scaffolding on Mathematics Conceptual Understanding and Procedural Fluency. *International Journal for Research in Education*, 1(2), 34-40.
- Kagan, S. & Kagan, M. (2009). Kagan Cooperative Learning. Kagan Publishing.
- Keles, O. & Ozsoy, S. (2009). Pre-Service Teachers Attitudes Toward Use of Vee Diagram in General Physics Laboratory. *International Electric Journal* of *Elementary Education*, 2 (3), 45-52.
- Knaggs, C.M. & Schneider, R.M. (2012). Thinking Like A Scientist: Using Vee-Maps To Understand Process And Concept In Science. Springer Science+Business Media.
- Koes H, S. (2013). Pengaruh Strategi Scaffolding-Kooperatif dan Pengetahuan Awal Terhadap Prestasi Belajar dan Sikap Pada Matakuliah Fisika Dasar. Jurnal Pendidikan Humaniora, 1(1), 245-255.
- Laili, A.M. (2014). Pengaruh Problem Based Learning Dengan Procedural Scaffolding Terhadap Pengua-

saan Konsep Fisika Pada Siswa Berpengetahuan Awal Tinggi dan Rendah. Tesis tidak diterbitkan. Malang: Program Pascasarjana Universitas Negeri Malang.

- O'Donnell, A.M., Donald, F.D. & Richard, H.H. (2002). Knowledge Maps as Scaffolds for Cognitive Processing. *Educational Psychology Review*, 14 (1), 123-133.
- Oh, P.S. & Shin, M. (2005). Student's Reflection on Implementation of Group Investigation in Korean Secondary Science Classroom. *International Journal of Science and Mathematics Education*, 3 (1), 327-349.
- Puntambekar, S. &Hubscher, R. 2005. Tools For Scaffolding Students in A Complex Learning Environment: What We Gained and What Have We Missed?.*Educational Psychologist* 40(1): 1-12.
- Reisslein, J., Reisslein, M. & Seling, P. (2006). Comparing Static Fading with Adaptive Fading to Independent Problem Solving: The Impact on the Achievement and Attitude of High School Student Learning Electrical Circuit Analysis. *Journal of Engineering Education* 1 (2), 345-354.
- Seery, M.K. (2009). The Effect of Prior Knowledge in Undergraduate Performance in Chemistry: A Correlation – Prediction Study. Dissertations. Paper 23. http://arrow.dit.ie/ltcdis/23.
- Taboada, A.& Guthrie, J.T. (2006). Contributions of Student Questioning and Prior Knowledge to Construction of Knowledge From Reading Information Text. *Journal of Literacy Research*, 38 (1), 1-35.
- Tekes, H. & Gonen, S. (2012). Influence Of V-Diagram On 10<sup>th</sup> Grade Turkish Students' Achievement In The Subject Of Mechanical Waves. *Science Education International*, 23(3), 1010-1021.
- Thompson, R.A. & Zamboanga, B.L. (2004). Academic Aptitude and Prior Knowledge as Predictors of Student Achievement in Introduction to Psychology. *Journal of Educational Psychology*, 96 (4), 778-784.
- Yu, F., Tsai, H. & Wu, H. (2013). Effect of Online Procedural Scaffolds and the Timing of Scaffolding Provision on Elementary Taiwanese Student's Question-Generation in a Science Class. Australian Journal of Educational Technology, 29(3), 45-55.



JPII 5 (1) (2016) 116-122

Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# THE EFFECT OF USING DIGIMON (SCIENCE DIGITAL MODULE) WITH SCIENTIFIC APPROACH AT THE VISUALIZATIONOF STUDENTS' INDEPENDENCE AND LEARNING RESULTS

# M.W. Syahroni<sup>1</sup>, N. R. Dewi<sup>2</sup>, Kasmui<sup>3</sup>

<sup>1</sup>SMP NU Al Ma'ruf Kudus, Indonesia <sup>2, 3</sup>Universitas Negeri Semarang, Indonesia

DOI: 10.15294/jpii.v5i1.5800

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

# ABSTRACT

The aim of this research was to determine the influence of digimon based scientific approach on independence and learning autcomes of learners. This research has designed as quasi-experimental nonequivalent control group design. Subjects of this reaserch is learners at 8 E and 8 F on SMP N 1 Magelang in year 2014/2015. The results showed that there was a strong perfect linear relationship between digimon with independent learning or learning outcomes of learners. The result of independent assessment on the experiment group was 85,47 while the result of independent assessment on the control group was 69,94. Digimon based scientific approach are influential 51.93% to the independence of learners, while the rest influenced by other factors. Digimon give influence 39.69% on learning outcomes of learners, while the rest influenced by other factors. This relation is empharized through an independent test (t-test) which shows dependent bridge between digimon with independence toward concept understanding of learners in experiment group.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: Digimon, Independent, Learning Outcomes, Scientific Approach.

# **INTRODUCTION**

Education is a systematic process to improve human capabilities holisticaly that allows our potentials (affective, cognitive and psychomotor) develop optimally. As quoted by Jaya (2012) the essence of education is an effort in preparing the students to face the environment which is always changing rapidly. Education is a trick in applying the principles of science and technology for the recreation of human beings. Education must be able to produce graduates who are able to think globally, and is able to act locally, guided by the moral and noble. Therefore, learning activities are designed to be able to provide a learning experience that involves mental

\*Alamat korespondensi: Email: mwidisyahroni110393@gmail.com and physical processes through interaction between learners, learners with educators, learners with the environment and with other learning resources in order to achieve the learning objectives.

Science learning objectives can be achieved when the learning process is understood by the learners. Students understanding of the science concepts, phenomena and natural events can be observed in through the processes of science done by learners. This means not only science learning in the form of declarative knowledge, but also learn about the procedural knowledge such as how to obtain information, scientific work habits, and thinking skills. The learning experience is realized through the use of learning approaches as well as a variety of learning media and students centered.

The approaches and learning media used by educators to manage the learning process plays an important role in the students' success during the learning process. The educators are trying to use fun science learning models to give the impression that science is fun, but it is not offset by the use of learning media or interactive teaching materials. The success of the learning process are influenced by the fit between the subject matter and level of students' thinking skills. According to Dahar, which was quoted by Nuroso & Siswanto (2010) Every individual will experience a level of cognitive development, Junior High School students in Indonesia can be stated to have the level of formal operational cognitive development, due to have an average age of over 11 years. At these levels, children can use concrete operations to form more complex operations (able to think abstractly). Another thing to note in the success of the learning process is the use of appropriate approach to construct knowledge.

The regulation of the Minister of Education and Culture / "Permendikbud" No. 65 Year 2013 on the Standard Process Primary and Secondary Education has signify the need for a learning process that is guided by the principles of scientific or scholarly approach. Tureni (2014) stated that the effort of applying scientific approaches in the learning process is often touted as the hallmark of the curriculum of 2013 and into its own power on the existence of Curriculum 2013, which is certainly interesting to learn and further elaborated. Scientific learning approach has the result that more effective and efficient when compared to learning by using the traditional approach (Wieman, 2007). According to Fauziah et al. (2013), the curriculum in 2013 learning process at all levels by using a scientific approach to students centered. In this case, the students' is required both in the search for other learning sources and dig more deeply about the key concepts that given by the educators in the school either from an online source or media interactive learning.

Nagpal et al. (2013) self-learning is a process, method and philosophy of education where the learners gain knowledge by their own efforts and develop capabilities for investigation and evaluation. Zimmerman was quoted by Field et al. (2014) categorizing learners have learning independence if learners are able to determine their approach to learning optimally and efficiently, is responsible for decisions that have been taken, and able to cooperate with others to expand their knowledge.

One of the lesson that uses a scientific approach is the science lessons. Until these days du-

ring a science lesson, it still seems difficult to be understood by the learner. This difficulty is due to the science material dense, full of memorization, and mathematical. Interactive teaching materials is one alternative to make the learning process more interesting and meaningful to learners. One of the teaching materials whic is suitable for visualing the science concept abstractness is to use interactive multimedia. Suheri (2006) provides a definition of multimedia is media that combine two or more media elements consisting of text, graphics, images, photographs, audio, video and animation in an integrated way.

Based on the results of preliminary observations in SMP Negeri 1 Magelang, 77% of students get more enthusiastic about learning if the learning process involves technology experienced in it such as flash animations, interactive video, and using a digital module. A module has advantages when compared to the textbook, which are on a two ways communication, a clear structure, a friendly and motivating. The advantages of digital module is easily accessible and are more relaxed when compared to the printed books that have been used in the learning process. The real condition of module is dominated by printed modules, while the electronic module is less used in learning. Pummawan (2007) in his research stating that the e-learning modules can enhance cognitive development and ICT skills. Pramana & Dewi (2014) in the development of research shows that the use of e-book learning can instill independence in learners, the independent learning classical learners score is 82.13% (independence).

Therefore, the writer conduct a research related to the use effects of the Digimon (digital module science), using science approach on the theme of Independence visualization and students learning score so they can improve students' spirit to learn independently outside of the school hours, and are able to improve the students' understanding concept. Scientific attitude can indirectly instilled in students through technology based scientific approaches based. Digital module is used to deliver material "Visualization", because the material is a lot of material that require visualization, especially in the discussion of the properties of light and shadow on the process of forming in the lens or mirror.

#### METHOD

This research was quasi-experimental with a non equalivalent control group design (Sugiyono, 2010). The population in this study were students of grade 8 second semester of SMP N 1 Magelang. The sample in this study were taken as much as two classes, the control and the experimental class. Samples were taken at random cluster sampling technique, to obtain grade 8 class E as control and 8 F as an experimental class. The method used to obtain the data consists of a documentation method used to obtain data on early learners who will serve as research samples; the test method uses posttest to obtain the learners concept understanding; and observation method is used to measure the learners' level of independence.

This study was started with observation to determine the problem and to analyse the situation, then constructed the product in the form of digimon. Digimon that had been developed subsequently validated by experts in materials, media experts and science teachers to determine the feasibility of digimon as teaching materials. Digimon was implemented in the experimental class while using the control class used students' worksheets, and finally the level of independence and the learning outcomes of students in both experimental and control class were measured. The results of the assessment of independence and learning outcomes of students in the experimental class then correlated with the response of students toward the digimon. Correlation coefficient calculation was performed to determine the level of influence of digimon towards independence and learning outcomes.

# **RESULT AND DISCUSSION**

Validation toward digimon was conducted by three experts: material experts, media experts, and science teacher. The results of this validation were used to determine eligibility of digimon with scientific approach as teaching materials before they were used for data retrieval. The scores of the assessment by material expert, media experts and science teacher were 94.74, 88.46 and 85.29 respectively with the average results of 89.50 in very good category. Results of each aspect of digimon assessment can be seen in Figure 1.

The assessment of learning aspect by material expert, media expert and science teacher obtained 91.25% with the criteria of very good. It was based on the appropriateness of learning components contained in digimon with the assessment criteria. The assessment criteria were the accuracy of the factual material contained in the digimon, digimon's relevance to the available resource material, as well as whether the use of digimon can stimulate independence and motivate learners in the learning process guided by scientific approach.

The content validity obtained a score of 96.43% within very good criteria. This indicated that the substance or the material contained in the digimon was in line with core competence and basic competences. The video and animation presented in digimon strongly supported the material. Practices with its key answers was seen as very helpful for learners to learn with visual theme.

For the display aspect, it achieved 87.50% with very good criteria. This was caused by the consistent design of display and could be viewed in an organized and attractive format to be used as teaching materials. Digimon was presented with moderate colour composition so as not to disturb the concentration when it was used. The type and size of the text used in the Digimon had been adjusted to facilitate readability for users. Digimon was also equipped with the navigation key, so that learners could easily operate digimon as learning materials.

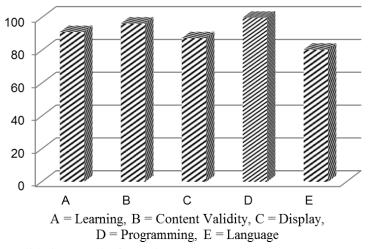


Figure 1. Digimon Validation Results for each Aspect

Programming aspects was only judged by media experts with value of 100% and fitted into the criteria very well. Programming aspect included programming across lesson components, the speed and accuracy of media response toward user commands. Each learning unit in digimon comes with pictures, video or animation related to the topic. The navigation buttons on digimon were designed using Bahasa Indonesia so that the users of these products could understand the function of each button appropriately. These buttons were very responsive to commands completed with the search box to find certain words or key terms contained in digimon.

Aspect of language was assessed by material expert, media expert and science teachers with value of 80.56% belonged to good criteria. Aspects of language assessment included the use of language, the use of the phrase, and the consistent use of terms or symbols. Digimon were presented in accordance with standardized Bahasa Indonesia and adjusted to the level of cognitive development of learners. The symbols in the digimon had been adapted to the symbols in other teaching materials, making it easier for learners to apply the formulas. Some foreign words or terms were also used in digimon, but foreign all lexis were explained and defined in the glossary.

#### Students' Responses toward Digimon

The responses of students toward digimon were taken using questionnaire sheet consisting of 12 statements with one to four scoring. Learners's responses were used to determine students' responses, especially on the theme of vision. The results of the analysis of the response of students to digimon were next correlated with independence and learning outcomes, to determine its effect towards the 2 aforementioned factors. The results of the analysis of students' responses toward Digimon can be seen in Table 1.

Learner response data to the Digimon presented in Table 1 indicated that the acquisition of the highest value of the response toward digimon was in the first statement, with a value of 92.50. This showed that students liked teaching materials in the form of digimon with scientific approach, due to the multimedia-based teaching materials incorporated with audio visual animations, video, and explanations related to the materials. The interest of students towards digimon with scientific approach on science teaching was evidenced by the acquisition of the statement "digimon makes me happy to learn science" with a value of 91.67. This is supported by research by Susanto et al. (2013) which states that the interactive media leads to high interests and activities of students and increase learners' understandin, with the achievement of 75% of the total learners passed minimum mastery score.

Learners responded with the lowest value of 77.50% as the answer for the statement "I believe I will score better in science after I use digimon". It showed that learners were not fully convinced to be able to increase their science scores due to the use of digimon in learning. The average responses score toward digimon was 89.94. This showed that the experimental class students responded positively to digimon with scientific approach used on the theme of vision.

Relationship between Digimon with Scientific Approach with Students' Independence in Learning

Table	1. Students'	Responses	toward	Digimon
-------	--------------	-----------	--------	---------

No	Statements	Mean
1	I like digimon	92.50
2	Digimon's presentation is very interesting	90.83
3	The language can be understood easily	89.17
4	The words do not cause multiple interpretation	82.50
5	I often access digimon	83.33
6	I am more motivated to learn using digimon	88.33
7	Learning with digimon helps me to understand the subject faster.	85.00
8	Digimon makes me happy to learn science	91.67
9	Digimon is very helpful in learning	90.00
10	Digimon makes my learning practical and enjoyabe	86.67
11	I prefer learning using digimon than using book	85.83
12	I believe I will score better in science after I use digimon	77.50
	Average	89.94

The results of the analysis of the observation toward students' independence showed that the average value of independent learning of experimental class is 85.47, while the control class scored 69.94. This indicated that the cultivation of independence toward learners in experimental class was higher than the control class, supported by t-test. These results are supported by research of Pramana and Dewi (2014), which revealed that the classical score of independence of learners of 82.13% was obtained from the use of e-book during the learning process. The independence level of experimental class was demonstrated through the acquisition of the percentage achievement of each aspect.

The obtained percentage on the aspect of the use of science teaching materials, the experimental class gained score of 89%, while the control group only reached 72%. This was because the experimental class in addition to using common teaching materials, they also used additional teaching materials from digimon and other books to support learning, and their awareness to use other supporting learning materials in experimental class categorized into good category, although there were some students in the control class that did not use additional teaching materials.

The percentage on aspects of assignment completions and self-evaluation in the control and experimental classes were 73%, 50%, and 78%, 80% respectively. Based on the analysis, the experimental group had a higher percentage than the control class for both aspects mentioned. This was caused by the digimon contained independent assignments to be done by the students in each sub-theme, and was accompanied by instructions to perform a self-assessment for learners. Class experiment also showed better results than the control class on aspects of asking questions, answering questions, and being active in discussions obtaining scores of 82%, 77% and 90% while the control group gained percentage of 65%, 57%, and 80 %. These results related to the design of digimon with scientific approach in a way that more learners demanded more active role in the learning process.

The percentage of readiness in practicum aspect for the experimental class and control class were 86% and 67%. This is because the digimon proposed young scientist activities in which learners require to take responsibility for any lab activities including preparing lab tools and tidying them up after being used. The aspect of seeking information from various sources and aspects of attention when learning in the experimental class had higher values than the control group (84% and 89% in the experimental class, and 56% and 78% in the control group). This might happen since digimon was equipped with animation and video that could be used to help students in understanding the subject, and to lead students to be more enthusiastic in participating in learning.

The high percentage of achievement for every aspect of each independence aspects of experimental class was in line with the proportion to the number of learners who belonged into very independent category of as presented in Figure 2.

There were 27 learners of experimental class and 2 students of control class who fitted into the category of very independent while the rest goes into the category of independent, quite independent and less independent. This shows that the scientific approach digimon could instill independence of learners. These results are supported by research of Oktiral et al. (2013) which states that the use of audio-visual media is proven to raise the independence of learners are keen to heed the lessons, and are motivated to learn so that learners show their active participation during learning process.

Other results obtained from this study were

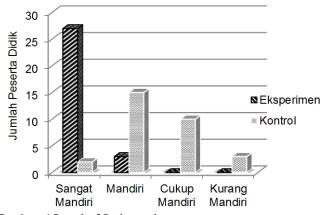


Figure 2. Review of Students' Level of Independence

the strong relationship between digimon and the independent learning of experimental class students. The correlation value is obtained from the value of the response of students to Digimon with the value of independence of experimental class students. The strength of the correlation relationship was demonstrated by the acquisition of the correlation coefficient (r) of the analytical results of 0.721 which meant that there was a direct perfect linear relationship between learners' response value toward students learning independence. The contribution made by digimon towards independent learning of students in the experimental class amounted of 51.93% while the rest was influenced by other factors. Linkage relationships were confirmed through independence tests (t test) which indicated the dependent or intertwined relationship between digimon with the independence of learners.

The strong correlation can occur because of learning by using digimon with scientific approach could lead students to be more enthusiastic in learning and stimulate learners to be able to actively participate in learning through scientific approach. This is supported by Fauziah et al. (2013) which states that the scientific approach can motivate and instill internal attitude on learners. Learners can also do a self-evaluation and determining the level of mastery of the concept toward the material that had been learned through independent tasks or evaluation contained in digimon to measure the achievement, particularly in learning on the vision theme.

This study showed that the use digimon in learning was effective to instill independence of learners compared with the use of textbooks in science of vision theme. This is because digimon with scientific approach taught materials in the form of a module that combines the approach with the development of technology and instructional media so as to increase the enthusiasm of learners and facilitate the planting of independence of learners in this modern times. This is supported by Nurlailiyah et al. (2014) which states that computer assisted learning media with a scientific approach is very feasible and attractive to be used in the learning process.

# The Relationship between Digimon with Scientific Approach with Students' Learning Achievement

The results showed that the use of digimon with scientific approach was able to strengthen the scientific understanding of the concept of the experimental class students in learning vision theme. This is supported by Kamaludin (2011) which states that learning by using the integrated science module can improve the understanding of the concept.

The average value of understanding concept of the control class and experimental class were 79.19 and 85.09. This indicated that the score of understanding concept of students in the experimental class was higher than the control class. Classical completeness of learners also showed the same thing, since 25 of 30 students in experimental class fell into the complete category (values over 81) and 16 of 30 students in control class belonged into the complete category. The positive achievement toward the results of experimental class was reinforced through a difference test (t test) which produced  $t_{count}$  of 3.84 t > t table of 1.67. This indicated that the average value of the experimental class obtained better results than the control class.

Other result obtained from this study was the strong relationship between the responses of students toward digimon with the level of concept understanding of the experimental class students. The responses affected up to 39.69% and 60.31% was the influence of other factors. This relationship was emphasized through independence tests (t test) which indicated the existence of a relationship between digimon to the understanding of the experimental class. This result meant that digimon as teaching materials was able to maximize the level of understanding of the experimental class students, especially on the vision theme, which required a lot of visualizations and animations. Digimon was a module that was developed in digital form with the use of technology, and equipped with animation and video that serves to facilitate learners in understanding the material. This is reinforced by research Nusir (2013) which revealed that the use of the program or multimedia and appropriate methods of learning can improve math skills.

Overall results of this study indicated that in addition to the digimon with scientific approach could embed learning independence, while provided a positive achievement toward students' understanding. One of factors which might lead to the acquisition of these results was digimon with scientific approach contained young scientist activity as well as the self-evaluation for the learners, thus stimulating learners to be more active in the learning process. It could help instill independence in learners. Digimon was constructed simply and interestingly to cultivate students' enthusiasm to use digimon. Digimon equipped with animations and videos facilitated learners to understand the material, thereby students' understanding toward the concept got better.

## CONCLUSION

Based on data analysis, it could be concluded that the digimon with scientific approach affected the independence and learning outcomes of students on the vision theme in SMP N 1 Magelang. Digimon brought a perfect linear relationship toward the independence and learning outcomes of students on the vision theme in SMP N 1 Magelang.

The researchers advice to further research to follow up this study is that in the making of digimon, you need to pay attention to the file extension being used, in order to facilitate learners in opening and studying it. It will be much better especially when digimon is available in .apk file and .ios for android and iphone so that it can be accessed through simple gadgets.

# REFERENCES

- Fauziah, R., A.G Abdullah. & D.L. Hakim. (2013). Pembelajaran Saintifik Elektronika Dasar Berorientasi Pembelajaran Berbasis Masalah. *IN-VOTEC Jurnal Pendidikan Teknologi Kejuruan*, IX (2), 165-178.
- Field, R. M., Duffy, James, Huggins & Anna. (2014). Independent learning Skills, Self-Determination Theory and Psychological Well-Being : Strategies for Supporting the First Year University Experience. In *International First Year in Higher Education Conference*, 6-9 July 2014, Darwin Convention and Exhibition Centre, Darwin, NT.
- Jaya, S.P.S. (2012). Pengembangan Modul Fisika Kontekstual untuk Meningkatkan Hasil Belajar Fisika Peserta Didik Kelas X Semester 2 Di SMK Negeri 3 Singaraja. *Jurnal Teknologi Pembelajaran*, 1(2). Tersedia di http://pasca.undiksha.ac.id/e-journal/index.php/jurnal\_tp/ article/view/301 [diakses tanggal 28-10-2014]
- Kamaludin, A. (2011). Pengembangan Modul Pembelajaran Sains Terpadu Untuk Meningkatkan Pemahaman Siswa SMP / Mts Tentang Zat Aditif Dalam Makanan. Tesis. Yogyakarta: Program Studi Pendidikan Sains Program Pascasarjana Universitas Negeri Yogyakarta.
- Nagpal, K., Priyamakhija, L. James & Gyanprakash. (2013). Independent Learning and Student Development. *International Journal of Social Science*

& Interdisciplinary Research, 2(2), 27-35.

- Nurlailiyah, S., H. Winarto, & Sugiyanto. (2014). Pengembangan Media Pembelajaran Berbantuan Komputer Dengan Pendekatan Saintifik (Scientific Approach) Pada Pokok Bahasan Fluida Statis Untuk SMA. Jurnal Pendidikan Fisika, 2(1). Retrieved from: http://jurnal-online. um.ac.id/article/do/detail-article/1/35/1470 [on 28-10-2014]
- Nuroso. H & J. Siswanto. (2010). Model Pengembangan Modul IPA Terpadu Berdasarkan Perkembangan Kognitif Siswa. *Jurnal Penelitian Pendidikan Fisika (JP2F)*, 1 (1), 35-36.
- Nusir, S., I. Alsmadi, M. Al-Kabi, & F. Sharadgah. (2013). Studying the Impact of Using Multimedia Interactive Programs at Children Ability to Learn Basic Math Skills. *E–Learning and Digital Media*,10(3): 305-319.
- Oktiral, Y.S., Ardipal, & J.L. Toruan. (2013). Penggunaan Media Audio Visual untuk Meningkatkan Kemandirian Siswa Belajar Seni Budaya. *E-Jurnal Sendratasik FBS Universitas Negeri Padang*, 2(1) Seri B : 63-72.
- Pramana, W.D. & N.R. Dewi. (2014). Pengembangan *E-Book* IPA Terpadu Tema Suhu dan Pengukuran untuk Menumbuhkan Kemandirian Belajar Siswa. Unnes Science Education Journal (USEJ), 3(3), 602-608.
- Pummawan, A. (2007). The Development of an E-Learning Module on The Sandy Shores Ecosystem for Grade-8 Secondary Students. *Educational Journal of Thailand*, 1(1), 95-110.
- Sugiyono. (2010). Metode Penelitian Pendidikan Pendekatan Kuantitaif, Kualitatif, dan R&D. Bandung, Indonesia : Alfabeta.
- Suheri, A. (2006). Animasi Multimedia Pembelajaran. Jurnal Media Teknologi, 2(1), 27-33.
- Susanto, N.R. Dewi & Andin I. (2013). Pengembangan Multimedia Interaktif Dengan Education Game Pada Pembelajaran Ipa Terpadu Tema Cahaya Untuk Siswa Smp/Mts. Unnes Science Education Journal (USEJ), 2(1), 230-238.
- Tureni, D. (2014). Penerapan Pendekatan Saintifik Berbasis Mind Mapping Dalam Mata Kuliah Fisiologi Hewan Pada Mahasiswa Pendidikan Biologi Universitas Tadulako. Jurnal Kreatif, 17(2), 25-29.
- Wieman, C. (2007). "Why Not Try Scientific Approach To Science Education?". Change: The Magazine of Higher Learning, 39(5), 9-15. Sep-Oct 2007. Retrieved from: http://eric. ed.gov/?id=EJ775137 [on 20-12-1014]



JPII 5 (1) (2016) 123-133

Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# TRANSFORMATION OF THE STUDENTS' INQUIRY CAPABILITY THROUGH MINDMAP EDUCATIVE BY USING GAME OBSERVATION NORMATIVELY (MEGONO) LEARNING MODEL

# Tasiwan

SMP N 1 Paninggaran Kabupaten Pekalongan, Indonesia

DOI: 10.15294/jpii.v5i1.5801

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

# ABSTRACT

This classroom action research was conducted to analyze the development of the students' inquiry abilities in science learning by a learning model of mindmap educative by using game observation normatively (Megono). The study was conducted in three cycles. In each cycle, the students were divided into five groups, each groups consisted of seven students. Each group was mandated to observe and to analyze the images/photos. After the image observations, they were asked to discuss, write and compile the information into a concept map. One of the students was act as a representative of the group in a game of observation. Data were obtained through the pre-test, post-test, and observation by the observers as well as from the photo and video recording. The results showed that the students' inquiry ability increased by 63.27% at the end of the cycle. At the initial conditions, the ability of the student was low (0.49). After the first cycle, it increased to 0.63 (medium), and then increased to 0.68 (moderate) on the second cycle, and finally it increased to 0.80 (high) in the third cycle. The average increase in every aspect was 68.59%. The highest inquiry capability was achieved in aspects of reasoning amounted to 89.29 (very high). It was suggested to use the observation games fairly and needed more time adjustment to obtain higher learning outcomes.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: inquiry, Learning model, MEGONO, mindmap.

# **INTRODUCTION**

National education system expects that the learning activities must develop the self-potential and curiosity of learners. Also, it should provide a learning experience that is supported by an active atmosphere, systematic and planned educational process. According to the rule No. 20 year 2003 of National Education System, education is a conscious and deliberate effort to create an atmosphere of learning and the learning process; therefore the learners are actively developing their potential to have the spiritual power of religion, self-control, personality, intelligence , noble character, and skills. By these self-potentials their soul can give the benefit for the mankind. The process of learning is a reciprocal relationship between teachers and students. In science, the learning required to develop their potential is a learning that grow and develop the ability of inquiry (inquiry skills) in the form of scientific processes, skills, reasoning, inquiry and problem resolution. Therefore, the ability of inquiry is seen as the key competencies to face the challenges of life and it serves as the curriculum standards of science education in the United States since 1996 started from the basic education level (Kuhn & Pease, 2016).

In class VIII A SMPN 1 Paninggaran, inquiry capability is one issue that needs to be solved urgently with the emergence of some cases. In the learning process, as much as 77.14% of the students were lack the independence and they were highly dependent on teachers to solve the

<sup>\*</sup>Alamat korespondensi:

Email: iwan1112000@yahoo.com

problems and to understand concepts. Moreover, 91.43% of students were not able to conclude or finding a concept, has a low learning retention. Furthermore, 74.28% of students were not able to design the experiments and they were having the difficulty on interpreting the student' worksheet independently. This condition was caused by the unavailability of the learning models that evokes inquiry capability in class VIII A SMPN 1 Paninggaran. In fact, in some cases it was found that basically, students had a pent inquiry capability that has not been developed properly. Students often expressed their thoughts when the conclusions/results of the analysis and investigation almost correspond with a confirmation from the teacher.

Inquiry capability is a skill and the logic units that can deliver the students to the scientific processes and scientific thinking (Pedaste et al., 2015). In some cases, the ability of inquiry is the development of an additional discovery with the mental processes that have a higher level in the form of asking questions and answers invention, linking the discovery with the other discoveries, and compare it with the findings of other students (Mulyasa, 2008). Therefore, the ability of inquiry is intimately associated with process skills and attitudes of science students that includes the student's ability to identify, to formulate questions and hypotheses, to predict, to plan and to carry out experiments, to collect and to analyze data, to interpret, to communicate and to present the results, and also to draw conclusions (Maeots et al., 2008; Harlen & Jelly, 1997).

Inquiry capability is a basic aspect of the development of dimension of cognitive, psychomotor and affective as well as problem solving. The wider effects of the development of inquiry capability is a major increase in cognitive abilities (cognitive priors), a scientific attitude, understanding and mastery of concepts, motivation, and critical thinking skills (A'yun et al., 2015; Kuhn et al., 2003; Kurniawati et al., 2014; Margiastuti et al., 2015).

The inquiry capability can thrive through the application of learning strategies that were able to construct knowledge and enable students in a series of learning activities that emphasize the process of critical thinking and analysis to seek and find their own answer to the problem in question (Sanjaya, 2006). According to Muslich (2008), the ability of inquiry will thrive in learning situations that emphasize skill development and involvement of the student to seek and find their own, foster self-confidence, open their intelligence and develop creativity, giving freedom to the students to take the initiative and act, encouraging students to think intensively and to formulate their own hypotheses, and the process of interaction as a student-centered learning.

Among the learning models that can be conditioned by the learning situation, mindmap as a learning model is in accordance with the characteristics of the concepts of science that able to develop appropriate skills to potential and inquiry capability (Balim, 2013). This is supported by the characteristics of the concepts of science as a series of concepts in synergy with each other. Skills needed in a particular concept require the ability on other underlying concepts. Therefore, mindmap is an appropriate strategy to construct knowledge and skills in a balanced manner.

Mindmap is a visual technique that describes the organization of the mind, memory development and problem resolution. This technique is used to interpret the content as much as possible specific and more abstract knowledge by organizing them into a network or a linear diagram associated with symbolic elements or verbal. In lessons, helpful mindmap to organize the knowledge, skills and abilities are more comprehensive. Besides functioning as a knowledge constructor, mindmap is a tool or a way to acquire the knowledge of students. It is based on the cognitive theory by Ausubel which of meaningfulness in learning (meaningful learning), which encouraged the teachers to know the concepts that have been owned by the students (Novak & Gowin, 1985). In lessons, mindmap can be applied for a variety of purposes including investigating the various things that have been known to the students, to learn how to learn, uncover misconceptions, and can be used as an evaluation tool.

Balim research results (2013) found that the mindmap technique used in the study could significantly improve the ability of inquiry, academic development, and retention of knowledge of students. Supported by the research results of Dhindsa et al. (2010), it was found that the cognitive abilities of students had improved by a conditioned learning through constructivism approach using visual mindmap on science topics. Their cognitive abilities were higher than students who taught by using traditional teaching that emphasizes the transmission of knowledge from expert teachers to students.

The development of student inquiry capability by a comprehensive mindmap approach is obtained through the activity of students in meaningful relationships between concepts expressed in the form of propositions, hierarchy and cross linkages (Novak & Musonda, 2001). Propositions are two or more concepts linked by words or elements in a semantic unit. The proposition is valid if it uses the common words or the right elements. Hierarchy is a common technique on concept drafting from a general concept to be more specialized and from inclusive to less inclusive. A more inclusive concept is placed on top and the less inclusive concepts laid out below, as well as a general concept is placed on top, while the concept is more specifically laid out below. Hierarchy is valid if the placement is in a correct order. The cross linkages is a significant association between a concept with one hierarchy with another concept in other hierarchies. Cross linkages is valid if it uses the conjunction or the right elements in linking the two concepts in a different hierarchy. Thus, students who apply mindmap can organize concepts based on the meaning and relationship between the components that had been developed in many dimensions of learning (Novak & Gowin, 1985). This condition will increase when the mindmap is constructed with the use of illustrations in the mindmap, elaboration of visual form of images, tables, charts, maps, flow, elements of line and color that helps the brain's neurons to construct, activate the thinking process and acts as well as increasing cognitive memory of up to 32% (Holliday, 2000; Toi, 2009).

As part of a cooperative learning model, mindmap is effectively solve the learning problems and may increase its effectivity when collaborated with other techniques. In some studies it was found that the influence of cooperative learning was increased when a collaborative strategy is done with methods or other approaches into a new learning model. The research reports from Joyce & Calhoun (2009) showed that an increase of academic ability reached 30% to 90% when cooperative learning model of collaboration with the inductive method of picture word inductive model. Syahrir research results (2011) stated that the jigsaw cooperative learning collaborated with team game tournament was effectively enhance the learning motivation and mathematical ability of students.

The learning model of Mindmap educative by using game observation normatively (megono) is the development of more comprehensive constructivism mindmap collaborated with a small scale team game tournament (TGT). The constructivism mindmap is a development of modern mindmap involving the student learning activity and an innovation in the use of illustrations, interpretation of the concept, diagram, colors, elements, and symbols to build students' knowledge independently (Dhindsa et al., 2010; Novak & Musonda, 2001). In findings by Maeots et al. (2008) suggested that the game simulation can significantly improve the aspects of inquiry capability. Supported by the results of Amin (2015) which stated that the tournament learning method had improved the students' performance and their motivation to learn physics.

The mindmap which was integrated in the quantum learining could improve the communication skills (Adhitama et al., 2015). The findings of Paykoç et al. (2004) stated that the mindmap with the group problem solving could improve the critical thinking skills. Moreover, supported by the research results of Pangestuti (2015), it was stated that mindmap collaborated with the team game tournament (Remap-TGT) was able to increase students' interest in reading biology textbooks to 76.90%.

### **METHODS**

The research object of this class action was a class VIII A in SMPN 1 Paninggaran with 35 students consisting of 14 male students and 21 female students with an average attendance rate of science subjects in the first semester of the school year 2015/2016 amounted to 97.86%. Based on the analysis of class condition in VIII A SMPN 1 Paninggaran, the carrying capacity of schools and curriculum gained an average by 2.2, whereas the carrying capacity was 2.2, and the complexity of science was 2.1, and the scoreof science minimum completeness target was 73,1.

According to the socio-economic conditions, the majority of students of class VIII A in SMPN 1 Paninggaran came from families with a livelihood as farmers, laborers, drivers, and small traders. A total of 22.86% or 8 students had parents as teachers or civil servants, and as much as 6 students or 17.16% of students were not living with their parents because their parents were migrated.

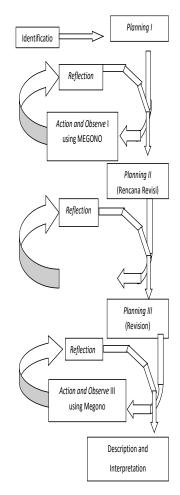
The research location was a school located in the highlands of Pekalongan district and bordering with the Banjarnegara district. The school environment was surrounded by residential areas, hills, heterogeneous forest, pine plantations, clove, and tea. A total of 514 students or 96.74% of students came from villages around the school in a district that consists of 14 villages, and as many as 17 students or 3.26% came from villages in Kali Bening Banjarnegara district, which borders the district of Pekalongan.

Research procedure used in this study was a classroom action research (action research) using Kemmis cycle model and Mc Taggart as shown in Figure 1. The implementation of a research was carried out by two stages included preaction stage and action stage. At the pre-action stage, the preliminary data were collected by inventoring the learning problems in class VIII A in SMPN 1 Paninggaran by consultation with the principal, curriculum assessment and planning the action. In the action stage, it was carried out the learning modification to the three cycles of learning. Each cycle was included in 4 steps, i.e. planning, action, observation, and reflection. In this study, megono was applied in the topic of digestive system in human.

Planning of the first cycle was performed by examining the basic competencies, competency standard, constructing the syllabi and Megono-based lesson plans, preparing the observation and evaluation instruments, setting up the equipments/materials, setting the place, and held the discussions with observers about the manner and process of data collection. The action stage was performed by dividing students into into 5 groups, each group consisting of 7 students. Each student in the group was asked to analyze the images/ photos. After that, they were asked to discuss and to write their thoughts on a media that had provided, to compile them into a mindmap. In addition, each group was given the opportunity to communicate by posting at an agreed place. Each group explored and assessed the results of other groups. The next phase, each group selected one of the students as a representative of the group in a game of observation.

Data were obtained through a pre-test, post-test, observation of the observers, as well as from the documentation of the photo/video. Indicators of success learning were if: (a) students' attendance reached 100%; (B) at least 90% of students showed the attention on Megono in the form of: active participation, curiosity, passion in the concept of conflict, like the challenge of making the mindmap, trying to complete the task to completion, following the observation game with enthusiasm; (C) at least 70% of students showed a progress in their inquiry capabilities include: curiosity, hypotheses and predictions, compile and execute an experiment, reasoning, finding and concluding, and roblems solving; (D) they were able to interpret the students' worksheet in group work, does not depend on teachers or other groups, capable of displaying mindmap, to study/comment on the work of other groups, and exceeded levels of difficulty in making mindmap, as well as appearing in game observation; (E) more than 80% of students were satisfied with the learning measured by: completing the

task on time, they were able to communicate the mind map, independent, creating programs in the constructing the mindmap, and they did not feel burdened with the task of mindmap; (F) reached the level of classical motivation through questionnaires votes for 75 out of 100; (G) one of the students were able to reach a value of 100 in the cognitive assessment; (H) at least 75% of students achieved the mastery level with 73 scores; (I) achieving an average value grade in the assessment of cognitive learning outcomes, amounting to 75 out of 100.

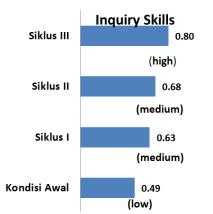


**Figure 1.** Research procedure conducted in Class VIIIA of SMP N 1 Paninggaran

# **RESULTS AND DISCUSSION**

# **Research results**

Based on the research and analysis of the data, it was obtained that through three cycles of Megono learning model, the students' inquiry capabilities were improved from 0.49 to 0.80 as shown in Figure 2. The mean average was increased in every aspect of the inquiry by 68.59%.



**Figure 2.**The development of students' inquiry capabilities through Megono learning model in each cycle

Based on Figure 2 it is found that the inquiry capability is increased significantly during each cycle of Megono action learning model. In the first action cycle, Megono learning model was able to improve students' inquiry for 28.57% of the initial state. Results of reflection on the first cycle induced the development of inquiry capability in students; therefore, in the cycle of action II the capability was increased by 38.78% from the initial conditions. Also, the result of reflection in cycle II was able to improve the inquiry in cycle III by 63.27% from the initial conditions.

The development of student inquiry capability was also marked by a shift in the percentage of students heading to high category mode and decreasing the percentage of students who were in a lower category on every aspect of inquiry capability. This condition was achieved after the performance of three cycles of Megono learning model as shown in Table 1. It is known that in the first cycle, the average number of students who have high category in the inquiry capability was 24.05%, while in the second cycle; the number of students who achieve high category was 67.14%. As for the third cycle, the number of students who achieve a high category was 88.09%.

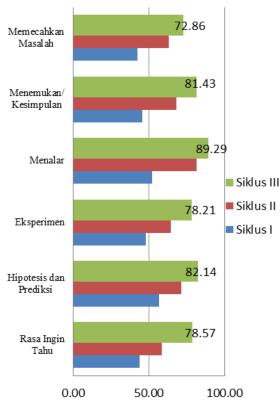
After finished three cycles of Megono learning models, it was found that there were no students with the low ability in five aspects included hypotheses and predictions, designing and carrying out experiments, reasoning, finding conclusions, and solving the problems. As for the aspects of the development of curiosity, 5.72% of the students were still in low capability condition.

Through Megono learning model, every aspects of the inquiry capability of students had increased as shown in Figure 3.The ability

Inquiry Sk	Pers	entase Si	swa	
Siklus I		Siklus II	Siklus III	
	High	24.31	54.28	77.14
Curiosity	Medium	51.43	22.86	17.14
	Low	24.26	22.86	5.72
	High	48.57	82.86	94.28
Hypothesis and prediction	Medium	31.43	5.72	5.72
prediction	Low	20.00	11.42	0
	High	8.57	34.29	85.71
Doing experiment	Medium	88.67	57.14	14.29
	Low	2.86	8.57	0
	High	25.71	100	100
Logical thinking	Medium	57.15	0	0
	Low	17.14	0	0
Finding/	High	11.43	80.00	97.14
C	Medium	62.86	11.43	2.86
conclusion	Low	25.71	8.57	0
	High	25.71	51.43	74.29
Problem solving	Medium	60.00	37.14	25.71
	Low	14.29	11.43	0

**Tabel 1.**Percentage of students in every aspect of inquiry capabilities development through Megono learning model

of inquiry that significantly improved was the ability to think logically by 89.29 score, whereas the smallest one was the ability to build by 72.86 score. According to the results, it can be stated that the Megono learning model was effectively improving the students' inquiry capabilities.



**Figure 3.** Achievement of each inquiry capability aspects in students through Megono learning model

Based on the observers' assessment and the analysis on the photos/videos and questionnaires showed that the development of inquiry capability achieved through Megono learning model was in line by the achievement of research indicators such as 100% students attended in each meeting, 95% of students had a concern in Megono learning model, 88.09% of students achieved an high level of inquiry capability after the third cycle, they were able to interpret the worksheet in group work, they could display the mindmap, also they were able to study/comment on the work of other groups, they coped with the difficulties in the construction of mindmap, they could actively and enthusiastically involve in the game observation, and 90% of students were satisfied with the learning. Moreover, the motivation level of students was high reached 81.38. Two students achieved 100 score in the cognitive assessment, while 82% of students achieved to master the basic competencies and the average score of cognitive assessment of all students was 78.

# Discussion

Based on the analysis of the research findings, it was obtained that Megono learning model significantly improved the ability of students in six aspects of inquiry include curiosity, hypotheses and predictions, doing experiment, reasoning/ logical thinking, finding/conclusion, and problem solving. This was due during the approach of Megono learning model, students gained opportunities as learners to explore the widest in analyzing images/photos, and then arranged them into a mindmap in accordance with their cognitive thinking way. Megono learning model provided the advantages of conditioning the class atmosphere to think and to explore freely. This condition could support the discovery and problem solving, improved the discussion atmosphere, increased the development of science skills and a competitive atmosphere, and also encouraged motivation and confidence of students.

In each cycle of Megono learning model, students had six learning experience that includes: (1) analyzing the photos/images; (2) preparing the questions based on photos/images; (3) solving the problems through discussion; (4) developing the mindmap; (5) observing the results of other groups; and (6) reinforcing the concept through the game of observation.

When students analyzed the images/photos, they had to interpret the atmosphere of free thinking, to take initiative, and to analyze the relationship between photos/images. This condition encouraged the students to well understand the basic concepts of learning materials and ideas. In effect, the curiosity of students grew along with the ability to predict and hypothesize. In the next phase, when students prepared the questions related to photo/images, their ability of inquiry was growing. The students' curiosity, hypotheses and predictions were assimilated with memory comprehensively; therefore it could strengthen and encourage them to think independently and take the initiative. This was evidenced by the ability of students to prepare questions independently and did not coincide with the other students' questions related to the image/photo. Students were able to cope with the difficulties and were able to explore the concept as much as possible and to think optimally (Crouch & Mazur, 2001; Kuhn & Udel, 2003; Kurniawati et al., 2014; Marshall, 2007; Wasis, 2008).

At a later stage, the students had a discussion to solve the problem. Discussion method en-

couraged students to think inclusively, they were able to work together, they dared to express and to receive opinions, they were able to compare the hypothesis personally with another student, they were able to admit their wrong opinions, they could actively seek information from a variety of learning resources, they could optimize their mastery on concepts, they invented the concept, as well as accepting the presence of other people. By this condition, students were able to improve their inquiry and decision making capabilities (Gokhale, 2004; Krulik & Rudnik, 1996).

At the stage of mindmap construction, the students performed a comprehensive activity in thinking, acting and being. It is influential in various aspects of the inquiry, including hypotheses and predictions, doing experiment, logic thinking, finding/conclusion, and problem solving. These aspects evolve in line with the activity of students in thinking and decision-making to determine the propositions, hierarchy and cross linkages (Novak & Musonda, 2001). Furthermore, the observation on the results of other groups' mindmaps and game observation generated the inquiry capabilities and better concept understanding in students. They were encouraged to have an organized and repeated reinforcement and growing the conceptual skills (Dindhsa et al., 2010). The satisfaction of students was appearing in their expressions, their hands gestures and screams when they could finish the mindmap compilation during the game observation. Learning situation was getting better with their reflection in every cycle and it supported by the advice and idea from the observer. This led to the development of more advanced and excellent of student inquiry capability during cycle II and III. Their ability ended up in the third cycle by high category.

#### CONCLUSION

Megono learning model had significantly improved the ability of inquiry of students in class VIII A SMPN 1 Paninggaran. Inquiry capability of students increased from a low condition into a high condition, especially in the aspects of curiosity, stating hypotheses and predictions, designing and carrying out experiments, thinking logically/reasoning, finding and stating the conclusions and solving the problems.

In this study, it was found that most of the students stated that their group was more right than any other group in one particular activity. Therefore, it is suggested to the teachers, they have to carry out a more precise and justice principled during the class and also could conduct an on time learning activity.

# REFERENCES

- Adhitama, N., Parmin& Sudarmin.(2015).Implementasi *quantum learning* berbantuan *mind mapping whorksheet* untuk mengukur kemampuan komunikasi dan hasil belajar peserta didik.*Unnes Sci ence Education Journal*,4(3),1022-1030.
- Amin, M., Mujasam&Widyaningsih, S.W. (2015).Pengaruh penggunaan metode *learning tournament* terhadap prestasi dan motivasi belajar fisika peserta didik SMA Negeri II Manokwari, Papua Barat. *Berkala Fisika Indonesia*,7 (2), 28-38.
- A'yun, Q., Dewi, N.R.&Sudarmin. (2015). Efektifitas model Think Pair Square (TPS) berbasis guided inquiry pada tema system transportasi untuk meningkatkan hasil belajar kognitif dan sikap ilmiah. Unnes Science Education Journal, 4(3), 973-982.
- Balim, A.G. (2013). The Effect of mind-mapping application on upper primary student's success and inquiry learning skills in science and environment education. *International Research in Geographical and Environmental Education*, 22 (4), 337-352.
- Crouch, C.H.& Mazur, E. (2001).Peer Instruction : Ten years of experience and result". *American Journal of Physics*, 69 (9), 970-977.
- Dhindsa, H.S., Kasim, M. & Anderson, O.R. (2010). Constructivist-Visual Mind Map Teaching Approach and the Quality of StudentsCognitive Structures. Jurnal Science Education Technology, 2 (3), 1-15. DOI 10.1007/s10956-010-9245-4.
- Gokhale, A. A. (2004).Collaborative learning enhances critical thinking. *Journal of Technology Education*, 7(1), 1-74.
- Harlen, W.& Jelly, S. (1997). Developing Science in the Primary Classsroom Essex. England : Addison Wesley Longman, Ltd.
- Holliday, W.G. (2000). Text Book Illustration : Fact or Filler ?.Journal Science Teacher, 57 (9), 27-29.
- Joyce, B., Weil, M.&Calhoun, E. (2009). Models of Teaching, Model-model Pembelajaran Edisi Delapan. Terjemahan Achmad Fawaid dan Ateilla Mirza. Yogyakarta : Putra Pelajar.
- Krulik, S.&Rudnik, J.A. (1996). The new source book teaching reasoning and problem solving in junior and senior high school. Massachutes : Allyn & Bacon.
- Kuhn, D.& Pease, M. A. (2016). What Needs to Develop in Development of Inquiry Skills? *Research-Gate in Cognition and Instruction*, DOI : 10.1080/ 07370000802391745, 1-74.
- Kuhn, D.&Udell, W.(2003). The development of argument skills. *Child Development Journal*, 74(5), 1245-1260.
- Kurniawati, I.D., Wartono& Diantoro, M. (2014). Pengaruh pembelajaran inkuiri terbimbing integrasi *peer instruction* terhadap penguasaan konsep dan kemampuan berpikir kritis siswa.

Jurnal Pendidikan Fisika Indonesia, 10 (1), 36-46.

- Maeots, M., Pedaste, M.& Sarapuu, T. (2008). Transforming Student's Inquiry Skills with Computer-based Simulation. *Proceeding*. 8<sup>th</sup> IIEE International Conference on Advanced Learning Technology, 1-5 Juli, Santander. Spain. DOI: 101109/ ICALT.2008.239
- Margiastuti, S.N., Parmin&Pamelasari, S.D. (2015). Penerapan model guided inquiry terhdap sikap ilmiah, dan pemahaman konsep siswa pada tema ekosistem. *Unnes Science Education Journal*,4 (3),1041-1049.
- Marshall, S.P. (2007). *Schemas In Problem Solving*. UK : Cambridge University Press.
- Mulyasa. (2008). *Menjadi Guru Professional, Menciptakan Pembelajaran Kreatif dan Menyenangkan.* Bandung : Remaja Rosda Karya.
- Muslich, M. (2008). KTSP, Pembelajaran Berbasis Kompetensi dan Kontekstual. Jakarta : Bumi Aksara.
- Novak & Gowin. 1985. *Learning How to Learn.* Cambridge; Cambridge University Press.
- Novak, J.D, &Musonda, D. (2001). A twelve-year longitudinal study of science concept learning. *American Educational Research Journal*, 28 (1), 117-153.
- Pangestuti, A.A., Misti'anah, Corebima, A.D. &Zubaedah, S. (2015). Using reading-concept map-teams games tournament (Remap-TGT) to improve reading interest of tenth grade student of laboratory senior high school state university of Malang. *American Journal of Educational Research*, 3 (2), 250-254.

- Paykoç, F., Mengi, B., Kamay, P. O., Onkol, P., Ozgur, B., Pilli, O.& Yildirim, H. (2004). What are the major curriculum issues ? : the use of mind mapping as a brainstorming exercise. *Paper*, dipresentasikan dalam The First International Conference on Concept Mapping, Spanyol.
- Pedaste, M., Maeots, M., Siiman, L.A., Jong, T.D., Riesen, S.A.N.V., Kamp, E.T., Manoli, C.C., Zacharia, Z.C.&Tsourlidaki, E. (2015). Phases of Inquiry-based Learning: Definitions and the Inquiry Cycle. *Educational Reaserch Review*,14 (1), 47-61.
- Sanjaya, W. (2006). Strategi Pembelajaran Berorientasi Standar Proses Pendidikan. Jakarta : Kencana Perana Media Grup.
- Syahrir. (2011). Effect of the jigsaw and team game tournament (TGT) cooperative learning on the learning motivation and mathematical skill of junior high school student. *Proceeding*. Disampaikan dalam International Seminar and The Fourrth National Conference on Mathematical Education, 21-23 Juli 2011. Yogyakarta. 155-168.
- Toi, H. (2009). Research on how mind map improves memory. *Paper*.Dipresentasikan dalam The International Conference on Thinking, tanggal 22 – 26 Juni 2009. Kuala Lumpur.
- Wasis, P. (2008). Penerapan Metode Pembelajaran Berbasis Proyek Untuk Meningkatkan Kualitas Pembelajaran Praktik Industri Pada Prodi S-1 PTB. Jurnal Penelitian Kependidikan, 18 (1), 204 – 215.

Appendix 1 The Grille and Questionnaire of Thinking Skills

Thinking Skills	Aspect	Scor
	A. Realizing Mind Your Own Way Consistent and accurate explain in detail a series of thinking used when faced with a task or problem and provides an analysis of how awareness of his way of thinking was evident from his appearance.	4
	Consistent and accurate explain how to think through tasks or problems and how awareness of the way he thinks it visible and appearance.	3
	Sporadic but accurately explain how to think through tasks or problems and how awareness of the way he thinks it is apparent from the appearance.	2
	Rare but accurately explain how to think through tasks or problems and how aware- ness of the way he thinks it appears from his appearance.	1
	B. Creating an Effective Plan Consistent make the right destination, consider and take into account all the short-	4
	term goals that are considered necessary and make a detailed implementation time. Consistent making purposes, pay attention to short-term goals, and create a detailed	4
	implementation time. Sporadic making purposes, pay attention to short-term goals, and create a detailed	2
	implementation time. Rarely when working on making purposes, pay attention to short-term goals, and cre- ate a detailed implementation time.	1
	C. Realized and Using Resources You Need Consistent display caution, detail to assess the resources required before starting the task. Repeat the resources available and consider alternatives. Anticipating the steps in a task that may be required as an additional source.	4
elf egulated	Consistent assess the project to identify which parts require resources. Repeats of alternative sources to determine whether it is suitable for the project.	3
hinking	Sporadic assess the project to identify the resources needed for the project, and often look for alternative sources.	2
	Rarely, if carried out to assess the project to identify the necessary resources and often seek alternative sources clear.	1
	D. Against sensitive Feedback Consistent sensitive to diverse feedback. Always respond appropriately when approach	4
	deemed does not work well and look for advice and other sources of knowledge. Consistent attention to the main source of feedback and responses are varied, making adjustments when necessary correction. Listening to the advice of others.	3
	Sometimes noticed the main source of feedback and responses are varied, making adjustments when necessary correction, listen to the advice of others.	2
	Rarely when done, pay attention to the main source of feedback. Rarely respond and make adjustments when necessary corrections. Do not pay attention to the advice of others.	1
	E. Evaluation of Effectiveness Measures Consistent repeat actions that have been done and the things that are considered use-	4
	ful, the evaluation of the impact of measures both short term and long term, finding good value in the lessons of success and failure. Consistent repeat the action and objective view reasonable, considering the short-term	3
	effects, and find lessons in his/her work. Sporadic repeat the action and objective view reasonable, considering the short-term	2
	effects, and find lessons in his/her work. Rarely repeats the action and objective view reasonable, considering the short-term	1

# Tasiwan / JPII 5 (1) (2016) 123-133

hinking kills	Aspect	Scor
	F. Accurate and Seek Accuracy Consistent attention to detail where appropriate, match the information on all impor- tant resource, recognizing inaccuracies quickly, and make the correction of errors,	4
	and clear. Consistent attention to detail, to test multiple sources, identifies and correct inaccura-	3
	cies.	
	Sporadic attention to detail, to test multiple sources, identifies and correct the inac- curacies.	2
	Rarely attention to detail, to test multiple sources, identifies and correct inaccuracies.	1
	G. Clearly and Seek Clarity Consistent creating a complete and free work and confusing elements.	4
	Consistent ereating a comprete and nee work and containing elements.	3
	Sporadic key element creates jobs free from confusing elements.	2
	Rarely key element creates jobs free from confusing elements.	1
	H. Open-minded Consistent overcome differences and divergent views and to consider alternative view- points in a fair and rational.	4
	Consistent aware of different views and always strive to consider alternative views.	3
	When aware of different views and sporadically sought to consider alternative views.	2
	Rarely aware of different views and infrequently seek to consider alternative views.	1
	I. Preventing Properties Impulsive Consistent and carefully consider the situation if it needs further study before doing	4
ritical	the work, if necessary, follow-up study, conducted detailed research before doing work.	т
hinking	Consistent consider the situation if it needs further study before doing the work; if necessary, follow-up study, gather enough information before doing work.	3
	Sporadic consider the situation if it needs further study before doing the work; if nec- essary, further studies, sometimes gather enough information before doing work.	2
	Rarely consider the situation if it needs further study before doing the work; if neces- sary, follow-up study, did not gather enough information before doing work.	1
	J. Taking Attitude When No Warranty	
	Consistent take appropriate attitude towards the situation, the value of which is dis- played and views are not revealed. In addition to providing strong evidence to support its position.	4
	Consistent take appropriate attitude towards the situation and the views were ignored. Always provide enough validation for his/her attitude.	3
	Sporadic take appropriate attitude towards the situation and a clear stance. Some- times provide enough validation for his/her attitude.	2
	Rarely take appropriate attitude towards the situation and a clear stance. Rarely pro- vide enough validation for his/her attitude.	1
	K. Noting feeling and level of ability of Others	
	Consistent shows insight to the feelings and the level of ability of others that appear when communicating. Always give positive impetus to such differences.	4
	Consistently shows ability to communicate with people of different feelings and knowledge and respect for the feelings, knowledge and abilities of others.	3
	Sporadic demonstrate the ability to communicate with people of different feelings and knowledge and respect for the feelings, knowledge and abilities of others.	2
	Rarely demonstrates the ability to communicate with people of different feelings and knowledge and respect for the feelings, knowledge and abilities of others.	1

Thinking Skills	Aspect	Score					
	L. In Constantly seek Completing Tasks Although the answer Could Not Anticipated Consistent shows the seriousness of reaching a solution, get involved. and develop and use many approaches to keep seeking duties	4					
	Consistent shows seriousness and approaches to keep seeking tasks.	3					
	Sporadic shows seriousness and approaches to keep seeking tasks.	2					
	Rarely demonstrates its seriousness and approaches to keep seeking tasks.	1					
	M. Encouraging Self-Yourself to Try Something Not Sure Can Do						
	Consistent look for challenging tasks and tasks to complete to complete or to gain						
	significant understanding.	4					
	Consistent accept existing challenges and tasks to complete to complete a task or to	2					
	gain significant understanding.	3					
	Sporadic accept existing challenges and tasks to complete to complete or to gain sig- nificant understanding. Rarely accept existing challenges and tasks to complete or to gain significant under-						
	Stunding.	1					
	N. Produce, Trusting, and Using Evaluation Standards for Work						
	Consistent generate personal standards for tasks that can raise the level of quality of	4					
Creative	the task and follow the standard in order to obtain the final product.						
hinking	Consistent generate personal standards for the task and follow the standard in order to	3					
	obtain the final product.	_					
	Sporadic generate personal standards for the task and follow the standard in order to	2					
	obtain the final product.	1					
	Rarely produces personal standards for the task and follow the standard in order to	1					
	obtain the final product.						
	O. Make a New Perspective Unlike the Perspective Generally						
	Consistent explore as many alternatives and resources that enable and analyze how	4					
	the alternatives affect the results obtained. Alternative describes a variety but a very						
	useful way to look at the situation.	2					
	Consistent yield approach to the task and clicking analyzes how these alternatives	3					
	affect the task. The alternative approach originally created as a student to complete the						
	task. Sporadic generating approach to the task and clicking analyzes how these alternatives	2					
		Z					
	affect the task. The alternative approach originally created as a student to complete the task.						
	Rarely produce and how to approach the task of analyzing how the alternatives affect	1					
	the task. The alternative approach originally created as a student to complete the task.	1					



JPII 5 (1) (2016) 134-139

Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# THE DEVELOPMENT OF RESEARCH-BASED PHYSICS LEARNING MODEL WITH SCIENTIFIC APPROACH TO DEVELOP STUDENTS' SCIENTIFIC PROCESSING SKILL

# Usmeldi

Universitas Negeri Padang, Indonesia

# DOI: 10.15294/jpii.v5i1.5802

## Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

# ABSTRACT

Physics learning in SMA N 2 Padang was implemented through theory and practicum for verifying the theories. The results of the initial survey showed that the physics teachers had not yet applied the research-based learning. Supporting facilities such as physics lab and its equipment has been already available, but it has not been utilized optimally. Research-based learning is a model that can improve scientific processing skills and learning outcomes of students. The research aimed to produce a valid, practical, and effective research-based physics learning model and devices. This research was a research and development using the 4D model of Thiagarajan. The instrument of this research are interview guides, observation sheets, sheet of validation of model and learning tools, questionnaire for both teachers' and learners' responses, assessment sheets for scientific processing skills, and achievement test. The results showed that the developed model and the learning devices according to the assessment of experts were declared valid. Model and learning devices were practical based on the observation and the questionnaires. The application of research-based physics learning could effectively improve scientific skills and learning outcomes of students. This model is suggested to physics teachers in high school in regard with implementing research-based learning.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: research-based learning, scientific, scientific processing skill.

# **INTRODUCTION**

Education is expected to produce students who possess the quality to live as a creative, innovative, intelligent, and globally competent individual. With respect to achieving national education goals, one of the Ministry of Education and Culture program is the development of Unit Level Curriculum (SBC) into Curriculum 2013. All levels of education within the frame of Curriculum 2013 is conducted using scientific approach. This studentcentered approach is designed in such way that the learners actively construct concepts, laws, and principles through the stages of observing, formulating problems, constructing hypotheses, collecting data, analyzing the data, concluding, and finally communicating the obtained concept, law, or principle (Kemendikbud, 2013). Scientific approach is intended to provide a sense of convenience for learners in mastering the subject. Therefore, the learning environments are expected to encourage students to be active in finding out the case from various sources through discussion, observation, and through the practicum activities.

Implementation of Curriculum 2013 with the scientific approach can be performed on all subjects, including physic subject. Physic examines many natural phenomena using scientific methods, so that it does not only focus on mastery of knowledge in the form of facts, concepts or principles, but also the experience during the invention process using the skills of physical processes (MONE, 2006). The process of the invention can be carried out through inquiry practicum

<sup>\*</sup>Alamat korespondensi:

Email: usmeldy@yahoo.co.id

activities. Wahyudin & Isa (2010) stated that the application of guided inquiry learning methods can increase interest and understanding of high school students. Practicum is an integral part of learning physics. Learners do not merely learn the theory and calculations using the formula but also doing practicum to deepen the concept mastery.

Laboratory activities provide live experience in learning physics and improve the skills in using the tools, solving problems, and logical thinking. Practicum in physic has its own advantages, whereas learners gain live experience, increase the participation of students either individually or in groups, learn to think through scientific methods or practice the work procedures based on the scientific method. Learning physics with practicum activities are effective to achieve the learning objectives in all competences simultaneously. It also trains the students to apply the theory to be applied into real problems (cognitive), uses instruments (psychomotor) and exercises scientific attitude (affective). One of the advantages of learning by practicum is that the learners can repeat the same activities until they find the correct results. Practicum can be carried out with the help of learner's worksheets corresponding with certain learning model. But the real practices show that the worksheets used by teachers in the school have not yet fulfilled the correct structure proposed by the Ministry of Education (2008). They have not yet been equipped with the usage instructions, supportive information to raise the curiosity of learners, and assessment.

Based on the results of preliminary studies at SMAN 2 Padang, it showed that 71.3% of physics teachers have already used the appropriate learning materials in accordance with the Curriculum 2013. However, not all lesson plans and teaching materials created by the teacher support the achievement of core competences and basic competence in the physics subject well. Teachers still use the common students' worksheet which does not fully support all of the discussions and practicum.

Overall characteristics of learners gained from data analysis of the five indicators achieved an average value of 62.5%. The observed characteristics are the ability to think critically (56%), cognitive learning style (58), interest (63%), learning motivation (66%), and scientific attitude (67%) during the physics lesson. Characteristics of students during the learning process will affect the achievement of the learning objectives of physics. This is indicated by the less optimal learning outcomes of students of class X SMA N 2 Padang in the first semester of the 2015/2016 academic year. The mastery level of for physics subject of class X MIA 1 only resulted 43.8% from 32 students while class X MIA 2 even obtained lower score of 31.3% from 32 students. This indicated that the learning completion in the classical style classes were still below 85%.

The students' lacking in mastering the concepts of physics is caused by students lacking necessary skills such as problem-solving skills, science processing skills, thinking and reasoning skills. The aforementioned lacking can be observed from the physics learning process which mainly used lecturing method in the form of theory description, elaboration of formulas with the aid of mathematical operations, and solving the problems through calculation. Reif (1995) stated that the informative learning method will result in ineffective learning process since students only acquire nominal knowledge of physics rather than functional one. Many teachers admit that the lecturing method in teaching physics fails to instil a deep understanding toward physics concepts (Hake, 1998; McDermott & Redish, 2009; Redish, 2003). As a result, students do not have the required skills to solve problems and are not able to apply the material they have learned.

Based on the problems encountered in school, it is deemed necessary to develop a model of learning tools such as lesson plans, students' worksheet, modules, and assessment. The worksheet needs to be developed as the guide of learning implementation that supports the achievement of competence of knowledge, attitudes, and skills for students. It contains several work steps including thinking process, working procedure, creativity, and independence to rediscover the concepts, principles, rules, and laws of physics. One model of learning that integrates research within learning to solve the problem of physics is research-based learning. Using this approach, students are guided to solve the problem based on the fact they encountered. Research based learning can be implemented with a variety of learning methods, so that all learning outcomes obtained by students are originated from a simple research they conduct, for example through experiments and field studies (Kynäslahti et al., 2006; Griffith, 2008; Jyrhämä et al., 2008; Ward, 2013). In physics, research based learning tend to be implemented in the form of practicum activities. By doing lab activities, students are expected to possess the scientific processing skills. This skill provides the students the opportunities to search for information, construct a hypothesis, collect data, analyze data, and make conclusions based on the live experience. The implementation of research based learning through practicum is for the students to have the scientific processing skills and character of a scientist.

Diah (2010) explains that the researchbased learning is inspired by the philosophy of constructivism that includes four aspects: learning that builds students' understanding, learning by developing prior knowledge, social interaction learning, and meaningful learning which will be achieved through live experience. Research based learning is an authentic learning (there must be real example), problem solving (answering case and contextual), cooperative learning (togetherness), contextual (hands on and minds on), and the inquiry discovery approach (discovering) grounded on the philosophy of constructivism in which the students' development is cultivated continuously and sustainably. Arifin (2010) claimed that the stage of research-based learning are as follows: exposure stage (introduction stage), lecturing of core knowledge (the step of administering a reference), experience stage (action stage), internal report for feedback (the discussion stage), and the final.

According to Wardoyo (2013), research based learning has seven characteristics implied in the learning process: systematic, active, creative, innovative, effective, objective, and scientific. Those 7 characteristics are in line with the nature of physics learning in curriculum 2013 with scientific approach. Yahya (2010) explains the advantages of research-based learning model are to give enough opportunity for students to observe, to formulate hypotheses, to collect and analyze the data, and to make conclusion. Research-based learning in physics can assist learners in constructing concepts or principles of physics, make the learning more meaningful through the application of scientific processing skill. The result of relevant research shows that the application of life skills oriented research-based learning can increase the activity and essential concept mastery in the Thermodynamics subject (Syakbaniah, 2013). The use of research-based students' worksheet in physics is effective to improve the competence of students at SMAN 1 Padang (Usmeldi, 2015).

Research-based physics learning with scientific approach is expected to improve the students' competence mastering the concepts of physics, scientific processing skills, and having the scientific attitude. In relation with the aforementioned facts, two research problems are formulated: (1) How is the development of research-based physics learning model with scientific approach to improve students' scientific processing skill? (2) How are the validity, practicality, and the effectiveness of the research-based physics learning with a scientific approach?

# METHOD

The study belongs to the research and development (R & D). Sugiyono (2011) suggested that research and development is a type of research methods used to produce certain product and testing its effectiveness. This study was conducted to obtain information about the users' needs (needs assessment), while the development activities was conducted to produce research-based learning model. The model used is the 4D development model by Thiagarajan. According to Thiagarajan in Trianto (2010), the stages of 4D are defining, designing, developing, and disseminating. The subject of the research is the physics learning model for high school students. The respondents are students and physics teachers at SMAN 2 Padang. The research instruments are the interview guides, observation sheets, sheet of validation of learning models, lesson plans, students' worksheet and assessment. All of those documents are based on the Instruction of Materials Development Guide (Ministry of Education and Culture, 2008). This research also uses questionnaires for teachers' responses and learners' responses, a test for learning outcomes, assessment sheets of scientific processing skill, and attitudes observation sheet.

Based on the collected data, it was analyzed qualitatively and quantitatively. Data of learning model validation, lesson plans, students' worksheet assessment, observation, questionnaires, and test results were analyzed descriptively and then compared with the criteria of validity, practicality, and effectiveness of the learning model. The learning implementation data were analyzed qualitatively by revising readability and action steps in students' worksheet. The revision was made based on the researcher's note, the results of observations toward the learning process, and also the opinions of experts and peers.

# **RESULT AND DISCUSSION**

# Research-Based Physics Learning Model with Scientific Approach

The research had produced a model of research-based physics learning with scientific approach. Research-based learning is a learning model that encourages research in the learning process. Research-based learning is ignited by the philosophy of constructivism that includes four aspects; learning that builds students' understanding, learning by developing prior knowledge, social interaction process learning and meaningful learning; in which all are achieved through live

No	Evaluated Aspects		Ex	perts	Maan	Catagory	
INO	Evaluated Aspects	FY	RL	AY	HY	- Mean	Category
1	Learning model	79	86	93	91	87,3	valid
2	Lesson plans	89	87	90	91	89,3	valid
3	Students' worksheet	98	91	95	96	95	valid
4	Assessment	85	90	98	92	91,3	valid

 Table 1. Results of Learning Model and Learning Tools Validation

 Table 2. Students' Learning Outcomes

No	Outcomes Aspects -		Mee	eting	Maara	Catagory	
		1	2	3	4	Mean	Category
1	Knowledge	78,3	80,2	80,8	85,4	81,2	Very Good
2	Skill	71,4	74,5	86,2	88,1	80	Good
3	Attitude	81,6	83,5	85,4	87,2	84,4	Very Good

experience. Research is an important means to improve the quality of learning. Research components consist of background, procedures, implementation, results, discussion, and publication. The six stages of research-based learning model are: (1) exposure stage, (2) the lecturing of core knowledge, (3) experience stage, (4) internal report for feedback, (5) presentation, and (6) final report ( Arifin, 2010). The research-based learning model is conducted using scientific approach.

# Validity of Learning Model

Research-based physics learning model was validated by three experts. The evaluated aspects were contents feasibility, construction feasibility, and language accuracy. The results of the validation of learning model and tools (lesson plan, learners' worksheets, and assessment) can be seen in Table 1.

The results of the validation of learning models, lesson plans, students' worksheets, and the assessment indicated that the learning model and the learning devices belonged to the valid category.

# The Practicality of Learning Model

The trial of learning model was conducted to obtain the data about the practicality of the model and the learning tools. The trial of the model was conducted in four meetings. During the trial, the researcher was assisted by physics teachers of SMAN 2 Padang as the observer. The teachers were in charge of observing the implementation of learning and learners' activity during the class. The practicality of the model was observed through the implementation of learning, and the responses of both teachers and learners. The results of the observations showed that the learning model could be implemented by teachers and learners well. Thus the researcher claimed that the research-based learning model with scientific approaches was practical.

# The Effectiveness of Learning Model

The outcomes of the studies in terms of knowledge showed an increase at every meeting. The average value of the outcomes in terms of knowledge is 81.2 and learning completion percentage is 89.8%. The average value of the students' skill is 80 and learning completion percentage is 86.5%. Students' attitudes reached a very good category with an average of 84.4. More than 85% of students had met the criteria of learning mastery standard. Thus it was proven that the developed learning model was effective in improving scientific processing skills.

The integration of scientific approaches into the research-based learning process conducted by adjusting the learning steps. Researchbased learning model with scientific approach generated in this study was pronounced valid, practical, and effective to improve the students' science skills. The results of this study are supported by the research conducted by Trisnasih (2013), and Xiaolai & Qinghuai (2011) in which they concluded that the application of researchbased learning can enhance the activity, processing skills, and students' learning outcomes in science lessons. Learning with scientific processing skill approach can improve learning outcomes and student learning activities (Haryono, 2006); Susiwi et al., 2009; Wardani et al., 2009). According to Ausubel (Ango, 2002) the activities which cause the students to conduct an investigation into lab activities will cause the learning to

be more meaningful and encourage the development of student competence.

Research-based learning model with scientific approach was conducted in the laboratory. The importance of laboratory activities was to understand the concepts of physics for students which also presented by Ivins and Raghubir. According to Ivins (McComas, 2005), practicum is more effective to help learners in studying the physics concept through the discussion. Raghubir (McComas, 2005) found that students showed a high level of cognitive ability when they directly acquire knowledge through practicum rather than using lab only for verifying the theory they have learned.

Practicum activities were more challenging for students in finding a physics concept compared to the verification activities. Cox (2002) and Jongdee (2009) in their study found that inquiry laboratory activities can improve the performance of students in doing practicum works. Deters (2005) and Weaver et al. (2008) in their study found that inquiry laboratory activities can improve the ability of students to think logically, solve problems, and provide a memorable experience in laboratory activities. Kurnianto et al. (2010) in his research concluded that learning physics with practical activities can develop students' ability to communicate the concept of physics. Inquirybased laboratory activities can enhance scientific processing skills of students (French, 2002).

Research-based physics learning with scientific approach could trigger the learners to master the competences of physics as a whole, not only the acquisition of knowledge and skills but also internalization of scientific attitudes and behaviour in everyday life, thus becoming their characters. Prayitno & Khaidir (2010) stated that the direct association with the character education leaded to 5i aspects, they are: faith and piety (iman dan taqwa), initiative (inisiatif), industrious (industrius), individuals (individu), and interaction (interaksi). Faith and piety includes obeying divine rules and religious life. Initiative means spirit, the willingness to initiate and to try, unyielding to achieve anything useful. Industrious means hard work, diligent, disciplined, productive, value-added considerations, honest, entrepreneurial spirit. Individuals include the potential quality, diversity and independence. Interaction implies the linkage of one individual with another individual.

The process of attitudes formation was assessed from the fulfilment of attitude indicators. This process could be observed that there was an increasing of number of those who enacted the intended attitude. The process of formation of an attitude basically require a long time, as stated by Nugroho (2011) that the establishment of attitude came with several steps that starts from dissatisfaction, followed by having a vision that is logical and rational, willing to take risks, and responsible to arrive on a consistent stage. At this last stage a change in attitude in a person is happening. It is certainly not an easy task given the numerous challenges faced by students every day. Therefore, in several meetings the level of consistency of the students' attitudes was difficult to be observed.

# CONCLUSION

This research had produced a researchbased learning model with scientific approach. Research-based learning is a model that encourages research in the learning process. There are six steps of research based learning, they are: exposure stage, lecturing of core knowledge, experience stage, the internal report for feedback, presentation, and final report in which all are integrated with scientific approach. The developed learning model is valid, practical, and effective to improve students' scientific processing skills. The attitude of the students belonged to the very good category. The knowledge and skills of learners reached over 85% degree of completion. The researcher recommends for physics teachers to apply this learning model. Further researches are necessary using different materials using the model that had been developed.

# REFERENCES

- Ango, Mary L. (2002). Mastery of Science Process Skills and Their Effective Use in the Teaching of Science: An Educology of Science Education in the Nigerian Context. *International Journal of Educology*, 16 (1), 11-30.
- Arifin, Pepen (2010). Research Based Learning. Prosiding Seminar Nasional. Bandung: Institut Teknologi Bandung.
- Cox, A.J., Junkin, W.F. (2002). Enhanced Student Learning in the Introductory Physics Laboratory. *Physics Education*, 37(1), 37-44.
- Depdiknas (2006). Kurikulum Tingkat Satuan Pendidikan (KTSP) Mata Pelajaran IPA SMP & MTS Fisika SMA & MA. Jakarta: Direktorat Jenderal Manajemen Pendidikan Dasar dan Menengah.
- Depdiknas (2008). *Panduan Pengembangan Bahan Ajar*. Jakarta: Direktorat Jenderal Manajemen Pendidikan Dasar dan Menengah.
- Deters, K. (2005). An Inquiry Lab on Inclined Planes. *The Physics Teacher*, 43(1), 177-179.

- Diah, T. W. dkk. (2010). Pedoman Umum Pembelajaran Berbais Riset (PUPBR). Yogyakarta: UGM.
- French, D., Russel, C. Nov. (2002). Do graduate teaching assistants benefit from teaching inquirybased laboratories?. *Bioscience.* 52(11), 1036-1043.
- Griffith. (2008). Research-Based Learning: Strategies for Successfully Linking Teaching and Research. University of Griffith.
- Hake, R.R. (1998). Interactive-engagement versus traditional methods: A six-thousandstudent survey of mechanics test data for introductory physics courses. *American Journal of Physics.* 66(1), 64-74.
- Haryono (2006). Model Pembelajaran Berbasis Peningkatan Keterampilan Proses Sains". Jurnal Pendidikan Dasar, 7(1), 1-13.
- Jongdee, Pintip Ruenwongsa (2009). "Guided Inquiry Learning Unit on Aquatic Ecosystems for Seventh Grade Students". Journal of Natural Resources & Life Sciences Education. Volume 38.
- Jyrhämä, R., Kynäslahti, H., Krokfors, L., Byman, R., Maaranen, K., Toom, A. & Kansanen, P. (2008). The Appreciation and Realisation of Research-Based Teacher Education: Finnish Students' Experiences of Teacher Education. *European Journal of Teacher Education*, 31(1), 1-16.
- Kemendikbud (2013). Konsep Pendekatan Scientific. Jakarta: Kemendikbud.
- Kurnianto, P., P.Dwijananti, &Khumaedi. (2010). Pengembangan Kemampuan Menyimpulkan dan Mengkomunikasikan Konsep Fisika Melalui Kegiatan Praktikum Fisika Sederhana. Jurnal Pendidikan Fisika Indonesia, 6(1), 6-9.
- Kynäslahti, H., Kansanen, P., Jyrhämä, R., Krokfors, L., Maaranen, K. & Toom, A. (2006). The multimode programme as a variation of researchbased teacher education". *Teaching and Teacher Education*, 22(2), 246–256.
- McComas, W. (2005). Laboratory Instruction in the Service of Science Teaching and Learning. *The Science Teacher.* 72(7). 24-29.
- McDermott, L.C. & Redish, E.F. (2009). Resource Letter, PER-1: Physics Education Research. American Journal of Physics, 67(9),755-767.
- Nugroho, Widyo Sulasdi (2011). Integrasi Pendidikan Berkarakter dalam Kurikulum MIPA dan Pendidikan MIPA. *Seminar Nasional FMIPA UNP*. Padang.
- Prayitno & Khaidir, A. (2010). *Model Pendidikan Karakter-Cerdas*. Padang: Universitas Negeri Padang Press.
- Redish E.F. (2003). *Teaching Physics with Physics Suite*. New York: John Willey & Son, Inc.

- Reif, F. (1995). "Millikan Lecture 1994: Understanding and Teaching Important Scientific Thought Processes". American Journal Physics. Vol. 63(1), 17-32.
- Sugiyono (2011). Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif dan R & D. Bandung: Alfabeta.
- Susiwi, Achmad A.Hinduan, Liliasari, & Sadijah Ahmad (2009). "Analisis Keterampilan Proses Sains Siswa SMA pada Model Pembelajaran Praktikum D-E-H". Jurnal Pengajaran MIPA Vol. 14(2) UPI.
- Syakbaniah. (2013). "Penerapan Research Based Learning untuk Meningkatkan Aktivitas dan Penguasaan Konsep Essensial Mahasiswa dalam Mata Kuliah Termodinamika". Prosiding Seminar Nasional Pembelajaran Fisika.
- Trianto (2010). *Model Pembelajaran Terpadu*. Jakarta: Bumi Aksara.
- Trisnasih, A.B., (2013). Peningkatan Keterampilan Proses dan Hasil Belajar IPA melalui Model Research Based Learning Siswa Kelas V SD. *e-Journal Program Pascasarjana Universitas Pendidikan Ganesha*, 4(1), 23-30.
- Usmeldi (2015). "Pengembangan Lembar Kegiatan Kerja Siswa dalam Pembelajaran Fisika Berbasis Riset di SMA N 1 Padang". *Prosiding Seminar Nasional Fisika*. FMIPA UNJ.
- Wahyudin, Sutikno & Isa, A. (2010). Keefektifan Pembelajaran Berbantuan Multimedia Menggunakan Metode Inkuiri Terbimbing untuk Meningkatkan Minat dan Pemahaman Siswa. Jurnal Pendidikan Fisika Indonesia, 6(1), 58-62.
- Wardani, Sri, Antonius, Tri, & Niken, E.P. (2009). Peningkatan Hasil Belajar Siswa Melalui Pendekatan Keterampilan Proses Sains Berorientasi Problem-Based Instruction. Jurnal Inovasi Pendidikan Kimia. 3(1), 391-399.
- Wardoyo, M.S. (2013). *Pembelajaran Berbasis Riset*. Jakarta: Indeks Permata.
- Weaver, Gabriela C., Cianán B Russell & Donald J Wink. (2008). Inquiry-based and researchbased laboratory pedagogies in undergraduate science. *Nature Chemical Biology*, 4(10), 35-45.
- Xiaolai, Liu & Qinghuai, Li (2011). Combination of the Research Based Learning Method with the Modern Physics Experiment Course Teaching, *Canadian Center of Science and Education, 4*(1), 102-112.
- Yahya, Iwan (2010). Manajemen Empat Langkah dalam Pengembangan Bahan Ajar Berbasis Riset: sebiuah pengalaman dari perkuliahan Akustik Jurusan FMIPA. *Makalah pelatihan Penulisan Buku Ajar Berbasis Riset*. Surakarta: LPPM UNS.



JPII 5 (1) (2016) 140-149

Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# ANALYSIS OF DIFFICULTY LEVEL OF PHYSICS NATIONAL EXAMINATION'S QUESTIONS

# Yusrizal

University of Syiah Kuala, Indonesia

# DOI: 10.15294/jpii.v5i1.5803

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

# ABSTRACT

This study aimed to determine: (1) the difficulty level of items in physics National Exam of 2013 (2) physics materials that were difficult and very difficult. The subjects were all students of science major in third gradeat SMAN Banda Aceh in the academic year of 2013/2014. The samples were 10 randomly selected senior high schools. The data were obtained through analyzing the answers of physics National Examin 2013. The results showed that (1) the high school students in Banda Aceh experienced difficult and very difficult level questions to be answer in the 2013 exam, (2) the difficult materials were: free fall, the potential energy and series of obstacles. The very difficult materials were: the rotational motion, motion and force on the pulley, effort, fluid, sound intensity, transformer, atomic theory, quantum theory, relativity, fusion and radio isotopes.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: item analysis, item difficulty, physics.

# **INTRODUCTION**

Measurement of learning results is conducted by the government embodied in the form of National Examination (Regulation of the Minister of National Education of Indonesia Republic Number 20 of 2007). National Exam is one of government efforts to spur an increase in the quality of education. Various studies indicate that by National Exam, students are encouraged to learn better and teachers are encouraged to teach better.

National Exam is used as a standardization tool to test the feasibility of a student to be able to continue his/her education to the higher level and as the distribution of education nationwide. The exam result is also used as a benchmark against other countries' education.

In relation to the learning outcomes, the instrumentscan be set as test or non-test. At high school National Exam, the measured outcomes

\*Alamat korespondensi: Email: yusrizal\_fkipunsyiah@yahoo.co.id are mostly cognitive score using written tests, whilst the behaviour in the form of affective and psychomotor is measured through School Final Examination (UAS), which uses both tests and non-test. The test is an instrument to detect the subjects that has not been well understood by students. In National Exam, it is a mean to determine the ability or student mastery of the material in accordance with the basic competences/standard competence.

After some time, the implementation of the National Exam should have been maximized. However, an unlikely phenomenon shows that the percentage of graduation of senior high school students who joinNational Examis not yet satisfactory. Sindonews.com, 26-05-2013, reported that Aceh and Papua province recorded the lowest graduationscore in NationalExam of 2013. Nationally, the number of unsuccessful rate ofsenior high school National Examwas 3.11 %, or 1,152 students. This numberwas the highest in Indonesia, followed by Papua province in second, and Central Sulawesi ranked third. In Banda Aceh city, the number of exam participants majoring in science was 1663 people, among them 42 people or 2,526% did not pass. From the education centre data, Banda Aceh resulted a relatively low Physics score ranges from 4.00 to 5.59 for 86 people or 5.17%, the range of 5.50 -5.99 for 23 people or 1.38%, and the range of 6.00 -6, 99 for 68 people or 4.09%.

Based on the data and the description can be concluded that students of SMA N of Banda Aceh encountered difficulties in answering the National Examof 2013 especiallyin Physics. Referring to the problem, the purpose of this study was to determine: (1) The level of difficulty of the questioninphysics National Exam 2013 for high school students in Banda Aceh, (2) The difficult or very difficult physics subjects for high school students in Banda Aceh. The results of this study can be used as input and consideration for physics teachers, Principal of SMAN, and the Education Service of Banda Aceh in improving the quality of teaching physics in senior high school.

A test is a measurement tool that is specifically used to know someone's cognitive abilities. Assessment by using written tests most commonly used to determine students' cognitive ability (Rofiah et al. 2013). Typically, when a student has completed a subject, some part of the lesson, or at the end of the lesson the teacher gives a test to measure the extent of understanding and the learning outcomes of individuals or groups. One function of the final exam is to certify that students have learned or mastered the skills as demanded by the curriculum (Siskandar, 2008).

Test as ameasurement technique can be interpreted as a gauge that has objective standard that can be used to calculate and to compare psychological circumstances or individual behaviours (Matondang, 2009). To measure student's ability to master a subject, the Government implements a form of test or evaluation through the National Examination. Implementation of the exam is the act of measuring the competence of graduates in terms of cognitive aspects nationally in primary and secondary education (Aisha, 2013).

The tests used in National Examare objective multiple choice test. Objective multiple-choice testcontains a set of questions with a number of possible answers to be chosen by the test taker. Examinees freely select an answer from the list so that the correction and scoring can be done objectively by the examiner. The checking of National Exam Answer Sheet (LJUN) is usually done using a scanner device.

National Exam's questions have been stan-

dardized by the National Education Assessment Centre (Puspendik). The device has gone through trial process in all area, so it is believed to have met all the requirements as a good test. The parameters that must be met for standardized tests are the validity, reliability, level of difficulty, differentiating power and decoys' effectiveness.

In this study, the sole tested parameter was the items level difficulty. The difficulty of the questions can be defined as the proportion of the number of test participants (students) who can correctly answer certain item (Boopathiraj and Chellamani, 2013). This proportion is usually expressed in terms of difficulty index in the rangeof 0.00 to 1.00 (Sabri, 2013). The calculation is done to each item. The greater the level of difficulty index obtained from counting means the easier it is answered. The difficulty index level is counted using following formula: Level of difficulty (p) = Amount of students answered correctly / Sum of all test participants (Widodo, 2010).

Physics National Exam is a written test in multiple choice forms with each question contain four choices. This type of test can be evaluated easily, quickly, and having high objectivity, measuring various cognitive levels, and can include a wide scope of materials (Ministry of National Education, 2007). Written test inthe form of multiple choice questions is widely used in exam with many test takers.

National Examination is a standard evaluation system for primary and secondary education nationally and equality of education level qualitybetween regions conducted by the Centre for Educational Assessment at the Ministry of National Education. Evaluation is an inseparable part of the learning process. Evaluation aims to find out, improve and enhance the quality of the learning process (Ratnaningsih et al., 2013). The evaluation is always preceded by the measurement activities, the process of determining the number according to certain rules, continued by assessment. Evaluation is done toward the measurement results and assessment information (Purnomo and Munadi, 2005). The measurement results on a score that describes the level of success of student learning based on predetermined criteria.

#### **METHOD**

This study is a descriptive diagnosis research. The subject (population) in this study were all students of high school3<sup>rd</sup> year science major of Banda Aceh in the education year of 2013/2014, while the samples were SMAN 1, SMAN 2, SMAN 3, SMAN 4, SMAN 5, SMAN 6, SMAN 7, SMAN 8, SMAN 10 and SMAN 12 Banda Aceh. Determination of the samples was conducted using random sampling techniques. The object is the level of difficulty of Physics National Examination items in 2013. The research was conducted on December 10<sup>th</sup>, 2013 until March 12<sup>th</sup>, 2014.

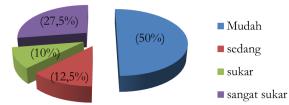
The designated instrument was the questions of Physics National Exam in 2013. The difficulty level of the data in the form of a response or answer of high school students in the academic year 2013/2014 were analysed with Microsoft Office Excel 2007. The classification of of difficulty level based on Safari (2012) as follows: 0.00 to 0, 30 is difficult; 0.31 to 0.70 means medium; and 0.71 to 1.00 is easy. In particular, the difficult level is divided into difficult and very difficult categories. If the difficulty level reaches  $\leq 0.25$ , it is considered extremely difficult (Kusaeri and Suprananto, 2012).

# **RESULTS AND DISCUSSION**

The results of the analysis of students' answers on the 10 high schools and the difficulty level of National Examination in 2013 for each school:

# SMA Negeri 1 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 1 are shown in Figure 1.



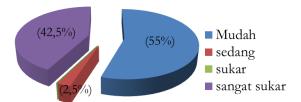
**Figure 1.** Difficulty level of National Exam in SMA Negeri 1 Banda Aceh

Difficult items were: item 2 (vector), item 3 (free fall), item 5 (motion on an incline), and item 34 (transformer). Very difficult items were: item 4 (rotational motion), item 6 (motion and force on the pulley), item 9 (effort), item 15 (fluid), item 30 (series of resistance), item 32 (magnetic field), item 36 (atomic theory), item 37 (quantum theory), item 38 (relativity), item 39 (fusion reaction), and item 40 (radioisotopes).

# SMA Negeri 2 Banda Aceh

Of the 40 items tested, the results of the

analysis of the answers for SMA N 2are shown in Figure 2.

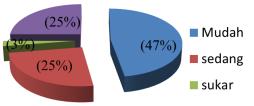


**Figure 2.** Difficulty level of National Exam in SMA N 2 Banda Aceh

The very difficult questions were: item 1 (measurement), item 2 (vector), item 3 (free fallmotion), item 4 (rotational motion), item 5 (motion on an incline), item 6 (motion and force on the pulley ), item 9(effort), item 15 (fluid), item 25 (sound intensity), item 31 (magnetic induction), item 32 (a magnetic field), item 33 (induction electromagnetic), item 34 (transformer), item 36 (atomic theory), item 38 (relativity), item 39 (nuclear reaction), and item 40 (radioisotopes).

# SMA Negeri 3 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 3are shown in Figure 3.



sangat sukar

**Figure3.** Difficulty level of National Exam in SMA N 3 Banda Aceh

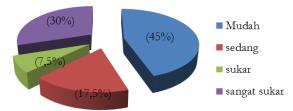
The difficult question was item 32 (a magnetic field) and the very difficult problems were: item 4 (rotational motion), item 5 (motion on an incline), item 6 (motion and force on the pulley), item 9 (effort), item 11 (potential energy) item 17 (temperature and heat), item 29 (series capacitor), item 38 (relativity), item 39 (fusion reaction), and item 40 (radioisotopes).

# SMA Negeri 4 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 4are shown in Figure 4.

The difficult problemswere:item 3 (free fall), 30 (series of resistance), and 31 (magnetic induction), and the very difficult questions were: item 4 (rotational motion), item 5 (motion on an

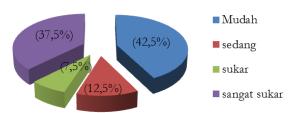
incline), item 6 (motion and force on the pulley), item 9 (effort), item 15 (fluid), item 25 (sound intensity), item 32 (a magnetic field), item 36 (atomic theory), item 37 (quantum theory), item 38 ( relativity), items 39 (fusion reaction), and item 40 (radioisotopes).



**Figure 4.** Difficulty level of National Exam in SMA N 4 Banda Aceh

# SMA Negeri 5 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 5are shown in Figure 5.



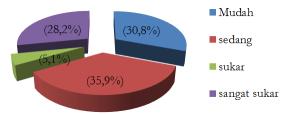
**Figure 5.** Difficulty level of National Exam in SMA N 5 Banda Aceh

The difficult problems were: item 1 (measurement), item 5 (motion on an incline) and item 38 (relativity. The very difficult items were: item 2 (vector), item 3 (free fall), item 4 (motion rotation), item 6 (motion and force on the pulley), item 9 (effort), item 15 (fluid), item 16 (temperature and heat), item 19 (thermodynamics), item 31 (magnetic induction), item 33 (electromagnetic induction), item 34 (transformer), item 36 (atomic theory), item 37 (quantum theory), item 39 (fusion reaction) and 40 (radioisotopes).

# SMA Negeri 6 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 6are shown in Figure 6.

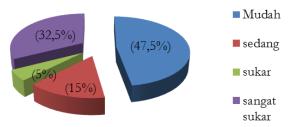
The difficult problems were item 2 (vector) and item 11 (potential energy), while the very difficult questions were: item 3 (free fall), item 5 (motion on an incline), item 9 (business), item 15 (fluid), item 17 (temperature and heat), item 26 (Coulomb's law), item 30 (series of resistance), item34 (transformer), item 36 (electromagnetic induction), item 37 (quantum theory) and item 39 (fusion reaction).



**Figure 6.** Difficulty level of National Exam in SMA N 6 Banda Aceh

# SMA Negeri 7 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 7are shown in Figure 7.

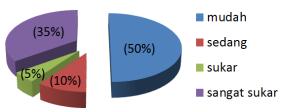


**Figure 7.** Difficulty level of National Exam in SMA N 7 Banda Aceh

The difficult problems were item 10 (elasticity) and item 29 (series capacitor). Meanwhile, the very difficult problems were: item 2 (vector), item 5 (motion on an incline), item 6 (motion and force on the pulley), item 15 (fluid), item 17 (temperature and heat), item 25 (the sound intensity ), item 30 (series resistance), item 31 (magnetic induction), item 34 (transformer), item 37 (quantum theory), item 38 (relativity), item 39 (fusion reaction), and item 40 (radioisotopes).

# SMA Negeri 8 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 8are shown in Figure 8.

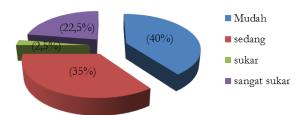


**Figure8.** Difficulty level of National Exam in SMA N 8 Banda Aceh

The difficult questions were item 17 (temperature and heat) and item 33 (electromagnetic induction). While the very difficult items were: item 2 (vector), item 3 (free fall), item 4 (rotational motion), item 5 (motion on an incline), item 6 (motion and force on the pulley), item 9 (effort), item 15 (fluid), item 31 (magnetic induction), item 32 (magnetic field), item 34 (transformer), item 36 (atomic theory), item 38 (relativity), item 39 (fusion reaction), and item 40 (radioisotopes).

# SMA Negeri 10 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 10are shown in Figure 9.

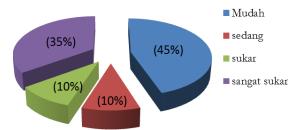


**Figure 9.** Difficulty level of National Exam in SMA N 10 Banda Aceh

The difficult problem wasitem 3 (free fall). The very difficult items were:item 4 (rotational motion), item9 (effort), item 25 (sound intensity), item32 (magnetic field), item 36 (atomic theory), item 37 (quantum theory), item 38 (relativity), item39 (fusion reaction), and item 40 (radioisotopes).

# SMA Negeri 12 Banda Aceh

Of the 40 items tested, the results of the analysis of the answers for SMA N 12are shown in Figure 10.



**Figure10.** Difficulty level of National Exam in SMA N 12 Banda Aceh

The difficult problems were: item 3 (free fall), item 11 (potential energy), item 17 (temperature and heat), and item 30 (series resistance). The very difficult items were: item 2 (vector), item 4 (rotational motion), item 5 (motion on an incline), item 6 (motion and force on the pulley), item 9 (effort), item 13 (collision), item 25 (sound intensity), item 33 (electromagnetic induction), item 34 (transformer), item 36 (atomic theory), item 37 (quantum theory), item 38 (relativity), item 39 (fusion reaction), and item 40 (radioisotopes).

Based on the research findings, we oncluded that the students still regarded physics as difficult subjects. Compared with other science material, students seem todislike the physics rather than chemistry and biology (Erinosho, 2013). Fauzi and Radiyono (2011) suggested that the results of several studies on students' perception toward physics showed that physics often regarded as a complicated subject. Johnson (2012) also stated that the difficulties faced by students in solving physics problems is linking the problem to other subject especially mathematics. Almost all of senior high school students in Banda Aceh found it extremely hard to solve items 36 (atomic theory), 37 (quantum theory) 38 (relativity), 39 (fusion reaction) and item 40 (radioisotopes), due to the abstract concepts underlying them. As it is known that there areboth abstract and concrete concepts in physics. Rahmawati et al. (2012) suggested that the abstract physics concepts are hard to visualize, making them difficult to be digested. Suzuk et al. (2011) added that physics is one of the most difficult lessons for its theoretical presentation, sometimes without the application of mathematical and abstract to everyday examples. According to Sabdin (2013), the unsuccessful effort of masteringthe concepts of physics are mainly caused by three things: (1) the nature of physics itself, (2) the implementation of the teaching is not good/appropriate, and (3) the character of the learning. The material abstract characteristicof physics causes student to have difficulties in studying physics concept unless it is associated with everyday experience.Sugiharti (2005) suggested that only by mastering the concept of physics, the entirephysics problem can be solved, both physical problem that exists in everyday life as well as physical problems in the form of questions, though the teacher still plays important role for the success of students. Barinto (2012) proposed that teachers are critical components in the success of an education because teachers are the spearhead in direct contact with students as subjects and objects of study. Physics as the basic science that will shape the analytical, logical and systemic mindset of students (Sunaryo, 2011), thus to learn and understand physics students must memorize, master the concepts of physics and have a strong mathematicalfoundation.

Item 9 (effort), 36 (atomic theory), 37 (quantum theory), 4 (rotational motion), 6 (motion and force on the pulley), 15 (fluid), 25 (sound intensity), and item 34 (transformer) were relatively concrete, but students find it very difficult, most likely because of the incorrect implementa-

tion of teaching. Ornek et al. (2008) showed that some factors causing physics become difficult can be categorized into: 1) a lack of motivation, interest, hard work and background knowledge, 2) Factors associated with learning, e.g. many assignments, class structure, not inadequate teachers, 3) factors related to the characteristics of the context of the physics of which is cumulative, abstract, involves a lot of things to learn, and requires a good understanding of mathematics. Physics as a subject related to the magnitudes of physical and mathematical calculations implies to almost all branches of physics resort to problem solving (Ogunleye, 2009).

here are two factors that could determine the success of students in answering questions in National Exam, they aremastering exammaterials and mastering the cognitive level of the questions. If the physics teacher rarelygavea high level C4, C5 and C6 problems in school exams because of the inability to construct it, students wouldsurely have difficulty answering the questions even though they master the materials. Results of research by Yusrizal &Zarlaida (2011) showed that the assessment components of student learning outcomes bycertified Physics, Chemistry and Biology teachers in senior high schools of Banda Aceh are still apprehensive. According to Munasco (2013) the factor of the teachers' qualification is considered as the most dominant and highly influences the learning outcomes of physics, and the test format will bring an impact on students' unsatisfactory learning outcomes.

#### **CONCLUSION**

Based on the analysis, the researcher can draw some conclusions: (1) The students of SMA Negeri Banda Aceh encountereddifficult and extremely difficult levels of questions in the National Examination of 2013, (2) materials that were perceived as difficult and extremely difficult by SMA N students of Banda Aceh were: fusion reaction, radio isotopes, rotational motion, motion and force on the pulley, relativity, fluid, sound intensity, atomic theory, quantum theory, and transformers.

#### REFERENCES

- Aisyah. (2013). Pengembangan Soal Tipe PISA di Sekolah Menengah Pertama. Jurnal Pendidikan Matematika Edumatica, 3(1), 27-34.
- Barinto. (2012). Hubungan Kompetensi Guru dan Supervisi Akademik dengan Kinerja Guru SMP Negeri Se-Kecamatan Percut Sei Tuan. Jurnal Tabularasa PPs Unimed, 9(2),201 – 214.

- Boopathiraj, C & Chellamani, K. (2013). Analysis of Test Items on Difficulty Level and Discrimation Index in the Test for Research in Education. *International Journal of Social Science & Interdisiplinary Research*, 2 (2), 189 – 193.
- Depdiknas. (2007). *Panduan Penulisan SoalPilihan Ganda*. Jakarta: Pusat PenilaianPendidikan Balitbang Depdiknas.
- Erinosho, S. Y. (2013). How Do Students Perceive the Difficulty of Physics in Secondary School? *Internationl Journal for Cross-Displinary Subjects in Education*, 3 (3), 1510 – 1514.
- Fauzi,A.& RadiyonoY. (2011). Pengembangan Bahan Ajar Fisika Dasar I Berbasis Spreadsheet dengan Pendekatan Analitik dan Numerik. Jurnal Materi dan Pembelajaran Fisika, 1(1),15 – 17.
- Johnson, N. (2012). Teacher's and Student's Perception of Problem solving Difficulties In Physics. *Internatonal Multidisciplinary e- Journal*, 2 (1), 17-22.
- Kusaeri & Suprananto. (2012). Pengukuran dan Penilaian Pendidikan. Yogyakarta: Graha Ilmu.
- Matondang, Zulkifli. (2009). Validitas dan Reliabilitas Suatu Instrumen Penelitian. Jurnal Tabularasa PPs Unimed, 6 (1), 87 – 97.
- Munasco. (2013).Bentuk Tes Formatif, Kualifikasi Guru dan Hasil Belajar Fisika dengan Mengontrol Kemampuan Awal. Jurnal Evaluasi Pendidikan, 4(1), 37 – 51.
- Ogunleye, A.O. (2009). Teachers' and Students'Perceptions Of Students' Problem-Solving Difficulties In Physics: Implications For Remediation. *Journal College Teaching & Learning*, 6 (2), 85 – 90.
- Ornek, F. R.& Hangan, M.P. (2008). What Makes Physics Difficult. International Journal of Enviromental & Science Education, 10 (2), 306-306.
- Purnomo, E.& Munadi, S. (2005). Evaluasi Hasil Belajar Dalam Implementasi Kurikulum Berbasis Kompetensi di Sekolah Menengah Kejuruan. Jurnal Cakrawala Pendidikan, 2 (1), 259 – 272.
- Rahmawati, Indrawati, Dina, H. R. (2012). Penerapan Model *Teaching With Analogies* (TWA) Dalam Pembelajaran Fisika di MA.*Jurnal Pembelajaran Fisika*, 1(1), 192 – 203.
- Ratnaningsih, Arrynda, Widianti, T.& Pukan, K. (2013), Analisis Kualitas Soal-Soal Try Out Ujian Nasional Mata Pelajaran IPA SMP di Kabupaten Banjarnegara, Unnes Journal of Biology Education, 2(1),34 – 40.
- Rofiah, E. Aminah, S. N.& Ekawati, Y. (2013).Penyusunan Instrumen Tes Kemampuan Berpikir Tingkat Tinggi Fisika pada Siswa SMP.Jurnal Pendidikan Fisika,1(2),17 – 22.
- Sabdin, A. K. (2013), Pengembangan Bahan Ajar Kinematika Untuk MeningkatkanKemampuan Multimodal Referensi, Darussalam (*Tesis*), Program Pascasarjana Unsyiah, tidak dipublikasi.
- Sabri, S. (2013). Item Analysis of Student Comprehensive Test for Research in Teaching String Ensemble Using Model Based Teaching

Among Music Studens in Public Universities. *International Journal of Education and Research*, 1 (12),1–14.

- Safari.(2012). Nilai UN dan Nilai Sekolah SMP DKI Jakarta Dalam UN 2010/2011. Value Jurnal Evaluasi& Asesmen Pendidikan, 1 (1), 1 – 15.
- Siskandar.(2008). Kesiapan Daerah Dalam Melaksanakan Ujian Nasional. Jurnal Ekonomi & Pendidikan,5 (1),95 -106.
- Sugiharti, P. (2005). Penerapan Teori Multiple Intelligence Dalam Pembelajaran Fisika. Jurnal Pendidikan Penabur, 5 (1), 29 – 42.

Sunaryo.(2011). Analisis Kompetensi Guru Fisika

Dalam Mengimplementasikan KTSP di SMKN Di Provinsi Lampung.*Jurnal Cakrawala Pendidikan*, 3 (2),505 -520.

- Suzuk, E., Corlu, M.A.& Gurel, C. (2011).Students' Perceptions of Learning Effienccy of Introductory Physics Course.*Eurasian Journal of Physics* and Chemistry Education, 2 (1) 65 – 71.
- Widodo. (2010). Analisis Butir Soal Tes. Jurnal Pendidikan Penabur, 14 (1), 58 – 67.
- Yusrizal, S.& Zarlaida, F. (2011). Evaluasi Kinerja Guru Fisika, Biologi dan Kimia SMA yang sudah lulus sertifikasi. Jurnal Penelitian dan Evaluasi Pendidikan,2(2), 269 – 286.

Appendix 1	The Grille and	Questionnaire of	Thinking Skills

Fhinking Skills	Aspect	Scor
	A. Realizing Mind Your Own Way	
	Consistent and accurate explain in detail a series of thinking used when faced with	
	a task or problem and provides an analysis of how awareness of his way of thinking	4
	was evident from his appearance.	
	Consistent and accurate explain how to think through tasks or problems and how	3
	awareness of the way he thinks it visible and appearance.	
	Sporadic but accurately explain how to think through tasks or problems and how	2
	awareness of the way he thinks it is apparent from the appearance.	1
	Rare but accurately explain how to think through tasks or problems and how aware-	1
	ness of the way he thinks it appears from his appearance.	
	B. Creating an Effective Plan	
	Consistent make the right destination, consider and take into account all the short-	
	term goals that are considered necessary and make a detailed implementation time.	4
	Consistent making purposes, pay attention to short-term goals, and create a detailed	_
	implementation time.	3
	Sporadic making purposes, pay attention to short-term goals, and create a detailed	~
	implementation time.	2
	Rarely when working on making purposes, pay attention to short-term goals, and	1
	create a detailed implementation time.	1
	C. Realized and Using Resources You Need	
	Consistent display caution, detail to assess the resources required before starting the	
	task. Repeat the resources available and consider alternatives. Anticipating the steps	4
	in a task that may be required as an additional source.	
	Consistent assess the project to identify which parts require resources. Repeats of	
elf Regu-	alternative sources to determine whether it is suitable for the project.	3
ated Think-	Sporadic assess the project to identify the resources needed for the project, and	2
ng	often look for alternative sources.	2
	Rarely, if carried out to assess the project to identify the necessary resources and often seek alternative sources clear.	1
	onen seek alternative sources clear.	1
	D. Against sensitive Feedback	
	Consistent sensitive to diverse feedback. Always respond appropriately when	
	approach deemed does not work well and look for advice and other sources of	4
	knowledge.	2
	Consistent attention to the main source of feedback and responses are varied, mak-	3
	ing adjustments when necessary correction. Listening to the advice of others. Sometimes noticed the main source of feedback and responses are varied, making	
	adjustments when necessary correction, listen to the advice of others.	2
	Rarely when done, pay attention to the main source of feedback. Rarely respond	2
	and make adjustments when necessary corrections. Do not pay attention to the	1
	advice of others.	-
	E Evaluation of Effectiveness Massures	
	E. Evaluation of Effectiveness Measures Consistent repeat actions that have been done and the things that are considered	4
	useful, the evaluation of the impact of measures both short term and long term,	4
	finding good value in the lessons of success and failure.	3
	Consistent repeat the action and objective view reasonable, considering the short-	5
	term effects, and find lessons in his/her work.	2
	Sporadic repeat the action and objective view reasonable, considering the short-	2
	SUDIALIC ICUCAL LIC ACTION AND UNICELIVE VIEW ICASUNATION CONSIGNATING THE SUDIF	
	term effects, and find lessons in his/her work. Rarely repeats the action and objective view reasonable, considering the short-term	1

148	Yusrizal / JPII 5 (1) (2016) 140-149
Appendix 1 The Grille and Que	stionnaire of Thinking Skills

Fhinking Skills	Aspect	Scor						
	F. Accurate and Seek Accuracy Consistent attention to detail where appropriate, match the information on all important resource, recognizing inaccuracies quickly, and make the correction of							
	errors, and clear. Consistent attention to detail, to test multiple sources, identifies and correct inac- curacies.	3 2						
	Sporadic attention to detail, to test multiple sources, identifies and correct the inac- curacies.	1						
	Rarely attention to detail, to test multiple sources, identifies and correct inaccura- cies.							
	G. Clearly and Seek Clarity Consistent creating a complete and free work and confusing elements.	4						
	Consistent key element creates jobs free from confusing elements.	3						
	Sporadic key element creates jobs free from confusing elements.	2						
	Rarely key element creates jobs free from confusing elements.	1						
	H. Open-minded Consistent overcome differences and divergent views and to consider alternative	4						
	viewpoints in a fair and rational.	2						
	Consistent aware of different views and always strive to consider alternative views. When aware of different views and sporadically sought to consider alternative	3 2						
	views.	1						
	Rarely aware of different views and infrequently seek to consider alternative views.							
	I. Preventing Properties Impulsive	4						
	Consistent and carefully consider the situation if it needs further study before doing the work, if necessary, follow-up study, conducted detailed research before doing	4						
ritical hinking	work. Consistent consider the situation if it needs further study before doing the work; if							
	necessary, follow-up study, gather enough information before doing work. Sporadic consider the situation if it needs further study before doing the work;	2						
	if necessary, further studies, sometimes gather enough information before doing work.	1						
	Rarely consider the situation if it needs further study before doing the work; if nec- essary, follow-up study, did not gather enough information before doing work.							
	J. Taking Attitude When No Warranty							
	Consistent take appropriate attitude towards the situation, the value of which is displayed and views are not revealed. In addition to providing strong evidence to support its position.	4						
	Consistent take appropriate attitude towards the situation and the views were ignored. Always provide enough validation for his/her attitude.	3						
	Sporadic take appropriate attitude towards the situation and a clear stance. Some- times provide enough validation for his/her attitude.	2						
	Rarely take appropriate attitude towards the situation and a clear stance. Rarely provide enough validation for his/her attitude.	1						
	K. Noting feeling and level of ability of Others							
	Consistent shows insight to the feelings and the level of ability of others that appear when communicating. Always give positive impetus to such differences.	4						
	Consistently shows ability to communicate with people of different feelings and knowledge and respect for the feelings, knowledge and abilities of others.	3						
	Sporadic demonstrate the ability to communicate with people of different feelings and knowledge and respect for the feelings, knowledge and abilities of others.	2						
	Rarely demonstrates the ability to communicate with people of different feelings and knowledge and respect for the feelings, knowledge and abilities of others.	1						

Thinking Skills	Aspect	Score					
	L. In Constantly seek Completing Tasks Although the answer Could Not Anticipated						
	Consistent shows the seriousness of reaching a solution, get involved. and develop and use many approaches to keep seeking duties	3					
	Consistent shows seriousness and approaches to keep seeking tasks.	2					
	Sporadic shows seriousness and approaches to keep seeking tasks. Rarely demonstrates its seriousness and approaches to keep seeking tasks.	1					
	M. Encouraging Self-Yourself to Try Something Not Sure Can Do						
	Consistent look for challenging tasks and tasks to complete to complete or to gain significant understanding.	4					
	Consistent accept existing challenges and tasks to complete to complete a task or to gain significant understanding.	3					
	Sporadic accept existing challenges and tasks to complete to complete or to gain significant understanding.	2					
	Rarely accept existing challenges and tasks to complete or to gain significant under- standing.	1					
	N. Produce, Trusting, and Using Evaluation Standards for Work						
Creative	Consistent generate personal standards for tasks that can raise the level of quality of the task and follow the standard in order to obtain the final product.	4					
Thinking	Consistent generate personal standards for the task and follow the standard in order to obtain the final product.	3					
	Sporadic generate personal standards for the task and follow the standard in order to obtain the final product.	2					
	Rarely produces personal standards for the task and follow the standard in order to obtain the final product.	1					
	O. Make a New Perspective Unlike the Perspective Generally	4					
	Consistent explore as many alternatives and resources that enable and analyze how the alternatives affect the results obtained. Alternative describes a variety but a very useful way to look at the situation.	4					
	Consistent yield approach to the task and clicking analyzes how these alternatives	3					
	affect the task. The alternative approach originally created as a student to complete the task.	2					
	Sporadic generating approach to the task and clicking analyzes how these alterna- tives affect the task. The alternative approach originally created as a student to	1					
	complete the task. Rarely produce and how to approach the task of analyzing how the alternatives affect the task. The alternative approach originally created as a student to complete the task.						

JPII 5 (1) (2016) 150-156



Jurnal Pendidikan IPA Indonesia



http://journal.unnes.ac.id/index.php/jpii

# IMPROVING STUDENTS' GENERIC SKILL IN SCIENCE THROUGH CHEMISTRY LEARNING USING ICT-BASED MEDIA ON REACTION RATE AND OSMOTIC PRESSURE MATERIAL

## S. Mulyani, Liliasari, Wiji, M. N. Hana, E. Nursa'adah

Indonesia University of Education, Bandung, Indonesia

DOI: 10.15294/jpii.v5i1.5804

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

#### ABSTRACT

The research aims to obtain information of improvement students' generic skills in science through chemistry learning using ICT-based media on reaction rate and osmotic pressure material. This research was designed with quasi-experimental research method, with the design of non-equivalent control group pretest-posttest design. The research subjects were students of class XI and XII one of Madrasah Aliyah Negeri (State Islamic Senior High School) in Bandung. Learning process in experiment group were conducted using ICT-based media, whereas in control group conducted by applying laboratory activities. Data were collected through multiple-choice test. The result shows that there was no significant difference of n- gain of students' generic skill in science between experiment and control group. Therefore it can be concluded that the learning process using ICT-based media can improve students' generic skills in science as well as laboratory-based activities.

© 2016 Science Education Study Program FMIPA UNNES Semarang

Keywords: Generic skills in science, ICT-based media, laboratory activities, osmotic pressure, reaction rate...

## INTRODUCTION

Knowledge grows fast so teacher needs to prepare or train their thinking skills to learn and understand the concept and does not only directly provide the concept. no longer enough just equipped with the knowledge or concepts. The appropriate skill for science covering chemistry skill inside is generic skill because it can be used to study material or other sciences independently. The generic term is used in terms of its potential and applied to various disciplines and contexts. Similarly Brotosiswoyo (2001) stated that the generic skill in science is the basic skill that is usefully used to learn other disciplines. According Liliasari (2009) generic skill in science as a new paradigm can make students learn science more easily.

More specifically Brotosiswoyo (2001) suggested that generic skill in science consists of

\*Alamat korespondensi: Email: srimulyani\_upi@yahoo.co.id direct and indirect observation, awareness of the scalar quantity, symbolic language, framework principles, consistent logic, inference logic, the law of cause and effect, mathematical modeling, and building concepts. The generic skill tends to be more specific on the necessary intellectual skill and is operated in acquiring and developing science related to its character. From the previous description it can be stated that the generic skill in science is skill that is related to the character of science, including chemistry.

Generic skill in science can be said as thinking skills therefore it can be learned and prepared to students through science learning. Chemistry, as well as other fields in science, is the study of natural phenomena. It discusses particularly on substance structure and composition, change of matter and energy that accompanies those changes. Chemistry is learned through the three levels of representation of macroscopic, sub-microscopic, and symbolic levels (Treagust, 2003; Sirhan, 2007; Talanguer, 2011).

Macroscopic level deals with descriptive knowledge of chemical substances and processes obtained directly (through the senses) or indirectly (using tools), and the experience of empirical knowledge that we understand and collect about chemistry system. This is consistent with Gilbert & Treagust (2009) that stated this type contains representation empirical properties of matter. It is also consistent with Johnstone and Gabel in Gilbert (2008) that stated the macroscopic level represents some aspects of natural phenomena that can be investigated. This level includes what is observed from what is learned.

Submicroscopic level is descriptive, explanatory and predictive of what has been developed of chemist to understand natural phenomena. Gilbert & Treagust (2009) stated that this level is associated with a model that can be explained the cause of phenomenon type. Chittleborough (2004) stated that the sub-microscopic level is as real as the macroscopic level, only the scale is different, and the fact that the sub-microscopic level can not be seen easily make it difficult to accept that it is real.

Symbolic level consists of static and dynamic visual signal (from symbol to icon) that was developed to facilitate qualitative and quantitative way of thinking and way to communicate both. Visualization relates to chemical formula and symbol, depictions of particulate, mathematical equation, graphic, animation, simulation, physical model, and so on, that visually represent a core component of theoretical model. Gilbert and Treagust (2009) stated that the level of symbolic involves the use of symbol to represent atoms, subscript that represents the number of atoms in ions or molecules, or letters to represent the physical state as solid (s), liquid (l), gas (g) and a solution (aq). Symbolic level consists of qualitative abstraction used to represent each item in a sub-microscopic level (Gilbert, 2008). As it grows, this type can be used to describe the type of model (such as: describing physical or chemical changes that occur during the reaction), it can also be used to describe the type of phenomena (such as: the number of reactants and products in the stoichiometry calculations). Symbolic representations are used extensively in the chemistry and used as a learning tool to help explain a macroscopic level and sub-microscopic level in chemistry. The symbolic representation of chemical phenomena includes chemical model as a model of ball-and-stick, space-filling models, structural formulas, chemical equations and computer models, or verbal descriptions,

diagrams, analogies, metaphors, images, ideas, or any simulations that can be used to develop students' mental models (Gilbert & Boulter in Chittleborough, 2004). Talanquer (2011) stated that the type of experience consists of empirical part, whereas the type of models and visualization consists of representation section.

Chemistry representation holds an important role, but on the other hand a lot of research show that students have difficulty in understanding submicroscopic representation (Tasker & Dalton, 2006). One of the ways to help them improving understanding of submicroscopic representation is by describing and visualizing processes occured at the molecular level (Sanger, 2000). Wu et al. (2001) research also showed similar results that students are helped by the use of computer-aided visualization tools.

Another difficulty experienced by students is to interpret representations, provide verbal explanation of chemical reactions, and make the translation between the different types of representation showing the weakness of the relationship/link between chemical phenomena, representations, and relevant concepts. Inspired by social constructivist learning, Kozma et al. (2000) suggested that the chemistry curriculum can guide students to use the plural representations visually and verbally to connect it with the phenomena. Compound representation should play an important role in the curriculum and chemistry learning. One of the ways that can be used to help students overcome this is studying the chemistry and its characteristics by using information and communication technology (ICT)-based media.

Computer technology, which is a product of information technology, is able to present the information in various forms such as text, graphic, image, animation, sound and video. The combination of various forms of information is known as multimedia. Ruthven (in Chiu & Wu, 2009) said that multimedia is a powerful communication tool in presenting science, especially natural science. Through video, students are given the opportunity to observe chemistry phenomena (macroscopic level). While, submicroscopic level, containing the explanation of macroscopic phenomena, can be presented through visualization in the form of animation and images.

Gilbert (in Chiu & Wu, 2009) stated that visualization through multimedia can combine students' mental imaginary that is formed when the acquisition of material can be observed and expectedly stayed in their long term memory. Multimedia can also visualize the interaction and dynamic movement that occur in the chemical process by displaying symbol and equation in three dimensions that can not be displayed by other media. The use of multimedia can provide valuable information for teachers about how students conclude, connect and integrate representation of macroscopic, submicroscopic and symbolic (Ardac & Akaygun, 2004).

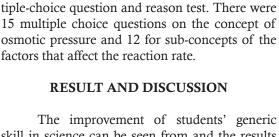
In line with the previous description of the problem formulation, this research applied learning using ICT-based media to improve the generic skill in science of high school students in studying chemistry. Chemistry materials used as media to develop generic skill in science were osmotic pressure and the reaction rate that was limited to the factors affecting it.

#### **METHOD**

This research designed was quasi-experimental research method, with the design of nonequivalent group pretest-posttest design. This design was selected because the sample can not be chosen randomly as experiment and control groups. So two classes that is already available of XI (reaction rate) and two classes XII (osmotic pressure) were directly used as experiment and control groups. This is in line with McMillan & Schumacher (2001) that stated that this design is very useful in education, since it often impossible to randomly assign subjects. The researcher uses intact, already established groups of subjects, gives a pretest, administers the treatment condition

60 50 40 30 20 10 Pre Tes Post N-Gain Tes

E = Experiment



to one group and Gives the posttest.

of their generic skill in science.

The study was conducted in one of Mad-

rasah Aliyah Negeri (State Islamic High School)

in Bandung. Experiment class was treated with

learning using ICT -based media, while control

group applied laboratory-based activities. Prior to the implementation of the learning process,

control and experiment group took the pretest to

determine their initial generic skill in science be-

fore joining the lesson. After the learning process

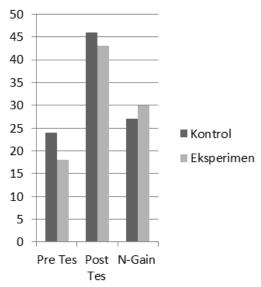
was conducted, at the end of the lesson students

were given posttest to measure the improvement

was done by using instrument in the form of mul-

Measurement of generic skill in science

skill in science can be seen from and the results of pretest and posttest data and normalized gain (n-Gain) of each research subject. The complete data of students' in experiment and control groups can be seen in Table 1 to Table 5. Achievement percentage of pretest, posttest and n-gain score average of students' generic skill in experiment and control groups can be seen in Figure 1a and 1b.



**Figure 1.a.** Achievement Percentage of Pretest, Posttest and N-gain Score Average of in Reaction Rate Material

**Figure 1.b.** Achievement Percentage of Pretest, Posttest and N-gain Score Average of in Osmotic Pressure Material

periment and Control Groups in Reaction Rate and Osmotic Pressure Materials.									
No	Topic	Pretest (%)		Postt	est (%)	n-Gain (%)			
No	Topic	С	Е	С	Е	C E			
1	Reaction Rate	29	23	49	43	27 24			
2	Osmotic Pressure	24	18	46	43	27 30			

**Table 1.** Percentage of Pretest, Posttest and N-gain Score Average of Students' Generic Skill in Experiment and Control Groups in Reaction Rate and Osmotic Pressure Materials.

Notes:

C = Control

E = Experiment

**Table 2.** Students' Score Percentage of Pretest, Posttest and N-gain of Each Generic Skill in Science (GSS) Indicator of Experiment and Control Groups in Factors that Influence The Reaction Rate Material.

GSS	Control Group			Experiment Group			
633	% Pretest	% Posttest	% n-Gain	% Pretes	%Posttest	% n-Gain	
GSS 1	35	45	8	17	32	10	
GSS 5	20	54	43	19	64	51	
GSS 6	27	27	-10	19	18	-7	
GSS 8	37	57	21	32	44	15	

Notes:

GSS 1: Indirect observation

GSS 5: Logical inference

GSS 6: The law of cause and effect

GSS 8: Building the concept

Generic skill in science (GSS) indicators examined in this research was adjusted to the character of material of factors that influence the reaction rate and osmotic pressure. GSS indicators developed on the concept of factors that influence the reaction rate are indirect observation, logical inference, the law of cause and effect, and building the concept; whereas the concept of osmotic consisting of indirect observation, symbolic language, the law of cause and effect, mathematical modeling, and building concepts. Achievement percentage of pretest, posttest and n-gain score average of each indicator of concept in experiment and control groups is presented in Table 2 and Table 3.

Table 2 shows that the generic skill in science of each indicator in experiment and control group generally has increased except at GSS 6 indicator (the law of cause and effect). On the concept of the factors that influence the reaction rate, the indicator of logical inference in the two groups has the highest value of n- gain (54% and 51%) compared to other indicators.

Table 3 shows that the generic skill in science of each indicator in experiment and control group on the osmotic pressure concept in generally has increased. The improvement of generic skill in the experiment group was in line with the results of Lilasari et al. (2008) and Liliasari (2009) that showed the generic skill in science can be improved by using multimedia-based learning. In the experiment group, GSS 6 of the law of cause and effect indicator had the highest value of n-gain (50%), whereas in the control group mathematical modeling indicator had the highest value of n-gain (63%).

T test using Independent Samples Test and non-parametric test using Wilcoxon test of n-gain of generic skill in science showed that multimedia-based learning on the factors that influence the reaction rate and osmotic pressure materials did not differ significantly in improving students' generic skill in science compared to the use of laboratory activities-based learning model.

T test resulted significance level value of 0,731 on the factors that influence the reaction rate concept and 0,763 on osmotic pressure concept. That value is greater than 0,05. From the analysis it can be concluded that the improvement of students' generic skill in science in both groups did not differ significantly. The statistics test results of each indicator are presented in Table 4 and 5.

Results of statistical analysis of each GSS indicator showed that there was no significant difference on the reaction rate topic, while for the

	Ex	Experiment Group			Control Group			
GSS	% Pretest	% Posttest	% n-Gain	% Pretes	%Posttest	% n-Gain		
GSS 1	8	55	49	25	58	43		
GSS 3	18	15	-7	19	33	14		
GSS 6	20	63	50	0	27	27		
GSS 7	13	40	37	18	81	63		
GSS 8	21	55	43	25	49	30		

**Table 3.** Students' Score Percentage of Pretest, Posttest and N-gain of Each Generic Skill in Science (GSS) Indicator of Experiment and Control Groups in Osmotic Pressure Material.

Notes:

GSS 1: Indirect observation

GSS 3: Symbolic language

GSS 6: The law of cause and effect

GSS 7: Mathematical modeling

GSS 8: Building the concept

**Table 4.** Statistics Test Result of Each Generic Skill in Science (GSS) Indicator of Experiment and Control Groups in Factors that Influence The Reaction Rate Concept

	Generic	Normality	· Test (α=0,	t-test/ non parametric test			
No Skill in		Significance Level		Caption	Caption		Notes
	Science	Con.Gr.	Exp.Gr	Con.Gr.	Exp.Gr	Level	
1	GSS 1	0,001	0,005	Not normal	Not normal	0,852	Not significant
2	GSS 5	0,553	0,126	Normal	Normal	0,364	Not significant
3	GSS 6	0,000	0,000	Not normal	Not normal	0.863	Not significant
4	GSS 8	0,174	0,021	Normal	Not normal	0,608	Not significant

Notes:

GSS 1: Indirect observation

GSS 5: Logical inference

GSS 6: The law of cause and effect

GSS 8: Building the concept

**Table 5** Statistics Test Result of Each Generic Skill in Science (GSS) Indicator of Experiment andControl Groups in Osmotic Pressure Concept

No Generic Skill in Science	Normality	Normality Test (a=0,05)				t-test/ non parametric test	
	Significance Level		Caption		Sig. Level	Natas	
	belenee	Con.Gr.	Exp.Gr	Con.Gr.	Exp.Gr	_	Notes
1	GSS 1	0,170	0,148	Normal	Normal	0,440	Not significant
4	GSS 3	0,142	0,005	Normal	Not normal	0,042	Significant
5	GSS 6	0,000	0,002	Not nor- mal	Not normal	0,122	Not significant
2	GSS 7	0,000	0,000	Not nor- mal	Not normal	0,048	Significant
3	GSS 8	0,902	0,399	Normal	Normal	0,121	Not significant

Notes:

GSS 1: Indirect observation

GSS 3: Symbolic language

GSS 6: The law of cause and effect

GSS 7: Mathematical modeling

GSS 8: Building the concept

osmotic pressure topic the significant difference was only in GSS 3 indicator (symbolic language) and 7 (mathematical modeling). This showed that ICT-based media in this study gave the same effective result as learning the method of direct experiment.

The almost similar result is derived from research conducted by Liliasari & Wiji (2012), but the subject was college student and it compared ICT-based media and inquiry learning. The result also showed that there was no significant difference between both groups.

Although Russell (1997) and Chow (1997) said that the model of ICT-based learning has the advantage of displaying image, video, photography, graphic, animation, text, and data, to make it possible displaying the chemistry concepts in three-level representation, but the results of this study indicate that such learning is as good as laboratory-based learning activities. Thus ICT-based media can be used as a practical substitute for schools that do not have laboratory facilities.

Since this research of laboratory based learning and ICT-based learning was condocted separately, it might need to be investigated further by integrating those methods. Kozma et al. (2000) research showed that computer-assisted representation can help students in describing their research in terms of the process that they expect to happen and chemical properties of substances resulting from their experiments. Based on these findings the same study with appropriate modifications for high school students can be done further to find out the result.

### CONCLUSION

Based on the result of implementation chemistry learning using ICT-based media on the topic of osmotic pressure and the factors that influence the reaction rate, it can be concluded that learning with ICT-based media was successful to provide the same effect as good as laboratorybased learning on generic skill in science improvement. The use of ICT-based media is better used to replace laboratory for schools that do not have the facility to improve GSS indicators of indirect observation, the law of cause and effect and building concepts.

For schools that have chemistry laboratory and computer facilities are suggested to involve students in using multiple representations (ICTbased) in conducting laboratory activities particular inquiry (either in asking questions, making predictions or stating the purpose of the investigation that they did. Its effectiveness can be tested further through further research to determine whether the laboratory-based learning integrated with the use of multi representation by computerassisted can provide better learning outcomes or not.

#### REFERENCES

- Ardac, D & Akaygun, S. (2004). "Effectiveness of multimedia based instruction than emphasizes moleculer representation students' understanding of chemical change". *Journal of Research in Science Teaching*, 41(4), 317-337.
- Brotosiswoyo. B. S. (2001). Hakikat pembelajaran MIPA di perguruan tinggi: Fisika. Dalam Tim Penulis Pekerti Bidang MIPA. *Hakikat pembelajaran MIPA dan kiat pembelajaran kimia di perguruan tinggi*. PAU-PPAT Dikti, Depdiknas.
- Chittleborough, G. D. (2004). The role of teaching models and chemical representations in developing students' mental models of chemical phenomena. (Tesis). Perth : Curtin University of Technology, Science and Mathematics Education Centre.
- Chiu, H & Wu, H-K. (2009). The role of multimedia in the teaching and learning of the triplet relationship in chemistry. *Model and Modeling in Science Education, 4*(1), 54-61. DOI 10.1007/978-1-4020-8872-8-12.
- Chow, V.W.S. (1997). Multimedia technology and applications. Singapura: Springer-Verlag Singapore Pte. Ltd.
- Gilbert, J. K. (2008). Visualization: theory and practice in science education. UK: Springer.
- Gilbert, J. K. & Treagust, D. (2009). Multiple representation in chemical education: models and modeling in science education. UK: Springer.
- Kozma, R., Chin, E., Russell, J., & Marx, N. (2000). The Roles of Representations and Tools in the Chemistry Laboratory and Their Implications for Chemistry Learning *The Journal of The Learning Sciences*, 9(2), 105–143.
- Liliasari. (2009). *The use of interactive multimedia to enhance students' generic science skills*. Paper. International Seminar on r-ICT ITB.
- Liliasari, Widodo, A., Setiawan, A., Juanda, E. A., (2008). The use of interactive multimedia to promote students' understanding of science concepts and generic science skills. *Formamente* , 3(1), 81-89.
- Liliasari & Wiji. (2012). Implementasi model-model pembelajaran berbasis TIK untuk mengembangkan keterampilan generik sains dan berpikir tingkat tinggi calon guru kimia, *Laporan Penelitian Implementasi Hasil Penelitian untuk Inovasi dan Pengembangan PBM*
- McMillan, J. G., & Schumacher, S. (2001). Research in education. New York: Longman.
- Nickerson, R. S. dkk. (1985). *The teaching of thinking*. New Jersey: Lawrence Erlbaum Associates Publishers.
- Sanger, M, J. (2000). Using particulate drawing to determine and improve student conceptions of

pure substances and mixture. *Journal of Chemical Education*, 77(6). 762-766.

- Sirhan, G. (2007). Learning difficulties in chemistry: An overview. Journal of Turkish Science Education, 4(2), 2-20.
- Talanquer, V. (2011). Macro, submicro, and symbolic: the many faces of the chemistry "triplet". *International Jurnal of Science Education*, 33(2), 179-195.
- Tasker, R. & Dalton, R. (2006). Research into practice: visualization of the molecular world using animation. *Journal of Chemistry Education Research and Practice*, *17*(2), 141-159.
- Treagust, D. (2003). The role of submicroscopic and symbolic representations in chemical explanation. *International Journal of Science Education*. *25*(11), 1353-1368.
- Russell, J.W. (1997). "Use of simultaneous-synchronized macroscopic, microscopic, and symbolic representations to enhance the teaching and learning of chemical concepts". *Journal of Chemical Education.* 74(3), 330-334.
- Wu, H-K., Krajcik, J. S., Soloway, E. (2001). Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom. Journal of Research in Science Teaching. 38(7), 821-842.