Jurnal Pendidikan Fisika Indonesia

Volume 14, Number 2, July 2018

TABLE OF CONTENTS

THE EFFECTIVENESS OF BASIC PHYSICS EXPERIMENT MODULE BASED ON GUIDED INQUIRY MODEL IN IMPROVING HARD SKILLS AND SOFT SKILLS OF PROSPECTIVE PHYSICS TEACHERS

Suprianto[1]*, S. I. Kholida[1], H. J. Andi[1], I. K. Mahardika[2]

[1]Faculty of Teacher Training and Education, Universitas Islam Madura, Indonesia
[2]Departmen of Physics Education, Universitas Jember, Indonesia

ABSTRACT

The purpose of this research is to identify the effectiveness of the first basic physics practice module based on guided inquiry on improving students' hard skills and soft skills. The experimental design is "One Group Pretest-Pottest Control Groups Design". The samples of the research are the students who take the first basic physics practice. Data analysis techniques were effect size and gain score. Based on the result of the research, it was found that the improvement of hard skills and soft skills of the students reached 0.49 and 0.61 which was categorized as moderate. For effect size obtained data of 2.65 and 3.61 for hard skills and soft skills are categorized very high. It can be concluded that the effectiveness of the use of the first basic physics practice module based on guided inquiry is very significant to improve hard skills and soft skills of the students.

ABSTRAK

Tujuan penelitian ini untuk mengidentifikasi keefektifan penggunaan panduan praktikum fisika dasar 1 berbasis guided inquiry terhadap peningkatan hard skills dan soft skills mahasiswa. Desain eksperimen yang digunakan adalah One Group Pretest-Postest Control Groups Design. Sampel penelitian adalah mahasiswa yang menempuh praktikum fisika dasar 1. Teknik analisis data yang digunakan adalah effect size dan gain score. Berdasarkan hasil penelitian diperoleh peningkatan hard skills dan soft skills mahasiswa mencapai 0.49 dan 0.61 yang berkategori sedang. Hal ini menunjukkan bahwa penggunaan panduan praktikum fisika dasar 1 dapat meningkatkan hard skills dan soft skills mahasiswa. Untuk uji effect size diperoleh data sebesar 2.65 dan 3.61 untuk hard skills dan soft skills yang berkategori tinggi. Dari hasil penelitian dapat disimpulkan bahwa kefektivitas penggunaan modul panduan praktikum fisika dasar 1 berbasis guided inquiry sangat efektif untuk meningkatkan hard skills dan soft skills mahasiswa.

Keywords: Guided Inquiry; Hard Skills; Soft Skills

INTRODUCTION

One of the efforts to improve the quality of education in Indonesia is by improving teaching and learning processes in all levels of education. There are some elements to improve the quality of education in Indonesia, such as curriculum, educational content, learning process, evaluation, teacher quality, facilities and infrastructure as well as textbooks.

Curriculum development is very important to improve the quality of education in order to produce graduates who are competent in their field. The curriculum development should encourage the formation of hard skills and soft skills. Hard skills is the ability to apply concepts, methods, and evaluations to improve the skills of learners. While soft skill is including the ability to communicate, work together in teams, leadership and problem-solving skills. Rosima & Melati (2012) stated that both skills (hard skills and soft skills) can be achieved in practical activities.

Rustaman in Purwaningsih (2014) desc-

*Correspondence Address:
Kompleks PP Miftahul Bettet Pamekasan, 69351
E-mail: suprianto@fkip.uim.ac.id

ribed that practice has several purposes: (1) to motivate students because the practice generally attracts students so they are motivated to learn science; (2) to teach basic scientific skills, (3) to improve understanding of concepts, (4) to understand and to use scientific methods, (5) to develop scientific attitudes. Meanwhile, according to Hodson in Abrahams (2011) there are 5 purposes of practical activities, they are: (1) to increase scientific knowledge, (2) to teach experimental skills, (3) to develop 'scientific attitude' like open minded, objective , and willingness to suspend judgment, (4) to develop skills, and to provide assessments, and (5) to motivate learners, with interesting and fun simulations. By doing practical activity students will be motivated, skilled and easy to understand the concept in physics learning.

Learning process contains 3 elements, namely attitude, knowledge, and skill. The final result of the development of these three element are that the learners have soft skill and hard skills. One way to achieve that ability is to carry out the practice well and correctly. To make sure that the practice will run well, one of the requirements is a practical guide module. According to Budi (2011) the practical guide module is a guideline for the implementation of a practice that contains the procedures for preparations, implementation, data analysis and report which is prepared by a person or group of teaching staff who handle the practice and follow the rules of scientific writing.

But in fact, even though there is a first basic physics practice module, there were only 1 until 3 students from 30 students of class 2015 who were able to formulate problems, to create hypotheses, to determine control, manipulate and response variables. While the ability to analyze and summarize the results of observations are also still less precise. Students always enter the basic theory or the results of observation while they were taking conclusions, whereas according to Riduwan, (2008) if we want to make a good conclusion, it is briefly expressed clearly and easily understood and must be in line and accordingly. It is not only hard skills are still low but also in soft skills found in this study. It is observed when the students communicate the results of the report, teamwork discussion, tenacity and curiosity of students in doing the first basic physics practice, but there is still one soft skill that is good, is honesty

The weakness of hard skills and soft skills of physics education students of Teacher and Education Faculty, Madura Islamic University of is caused by several factors such as the input of physics students. Most of them were come from from senior high school/vocational/MA with various majors. Students from SMA/MA, they have experience in learning Science. Social Science and language, while the students who came from vocational school, they have other majors. Based on the reason the students' hard skills about physics subject are still low.

In addition, practical activities emphasize more on the outcome (product) rather than on the process, so that few opportunities are given to the students to do some experiences based on their own efforts in developing hard skills and soft skills. Whereas as a candidate of future teacher who will teach physics highschool students, they need more experience and develop their scientific work skills. So that, later they can guide students to perform independent experiments in learning science in school, gain knowledge, which will make it easier to test, modify, to change the initial ideas that have been owned, and to adopt new ideas as well as to encourage the development of hard skills and soft skills of their students. Based on the results of the study the first basic physics lab used by physics education students FKIP Islamic University of Madura does not encourage students to train their hard skills and soft skills. This is because the first basic physics is still conventional with the guidance of the prescription model (cook book) so that the students are less active in the lab activities.

One of the efforts to solve these problems is to develop the first basic physic practice module based guided inquiry. The selection of the module development gave the advantages of guided inquiry that can form the student's "Self Concept", develop individual talents or abilities, giving students the freedom to study. Guided inquiry is one type of inquiry learning. Teachers were provide problems to be investigated along with the tools and materials to be used for experiments, but students plan themselves a procedure to solve the problem.

Guided inquiry can train learners to build answers and think smartly in finding various alternative solutions to the problems raised by educators; develop conceptual understanding skills; build a sense of responsibility; and train the process of conveying the concept found (Bilgin, 2009). Meanwhile, based on research Ariesta & Supartono (2011) it s found that the form of lectures of basic physics laboratory 2

activities based on guided inquiry learning model can improve the scientific work of students. It is in line with the results of Nengsi (2016) research that the guidance of general biology-experiment based on guided inquiry learning model for biology students of STKIP Payakumbuh was valid, practical, and effective. This is apparent in the activities of students who are active in conducting practical activity using guided inquiry guide. The same opinion was also shown in a study conducted by Nurussaniah (2016) which concluded that there was an increase in students' critical thinking skills after using the first basic physics practice module based on guided inquiry categorised of medium with a N-gain value of 0.64.

Based on the above description it is necessary to improve hard skills and soft skills of prospective physics teacher through the first basic physics practice module based on guided inquiry.

METHOD

This research was conducted in two stages, the first phase was the development of the first basic physics module based on guided inquiry using the modified Borg & Gall (2003) development model and the second stage was the experiment in the class, in the implementation the first basic physics module based of guided inquiry. In the first stage, developed the first basic physics practice module based on guided inquiry which has been validated by experts in the field of education and has been tested on a small scale. The results of the validation of the experts stated that the first basic physics practice module based on guided inquiry is very significant to use.

In the second phase of large-scale, experiments using experimental research. The experimental design used was "One Group Pretest-Postest Control Groups Design" (Schreiber, 2011). This research was conducted at the integrated laboratory of Madura Islamic University. The population in this study are all students of physics education program of Madura Islamic University, while the research sample is students in Odd Semester Academic Year 2017-2018 which take the course of the first basic physics practice. The instrument used in this research is an expert validation sheet on the first basic physics practice module based on guided inquiry, hard skills assessment sheet and student soft skills, students' response and questionnaire.

Analysis of the result of hard skills assessment and soft skills of students were conducted by using gain score test. A normalized gain score test is a good method for analyzing pre-test and post-test results. N-Gain Score is a good indicator to show the level of effectiveness by analyzing pre-test score and post-test scores. By adapting Hake's theory of a normalized gain score, the effectiveness of the use of guided inquiry guidelines in the first basic physic practice module based on guided inquiry on hard skills and soft skills of students could be determined.

To find out the improvement of hard skills and soft skills of students in the subject of the first basic physics practice used the average score data <g> processed by using the equation developed by Hake (1999), as follows.

$$<g> = \frac{<S_{post}> - <S_{pre}>}{S_{m\ ideal} - <S_{pre}>} \tag{1}$$

The <g> category is presented in Table 1

Table 1. Category Level <g>

LIMITATION OF N-GAIN	CATEGORY
<G> > 0.70	HIGH
0.30 ≤ <G> ≥ 0.70	MEDIUM
<G> < 0.30	LOW

Effect size is calculated using the formula (Cohen, 1998) as follows,

$$d = \frac{M_{posttest} - M_{pretest}}{\sqrt{\frac{SD^2_{posttest} + SD^2_{pretest}}{2}}} \tag{2}$$

where:

M   : : Average test scores

SD   : : Standard deviation test scores

The value of the effect size (d) obtained is interpreted using the following Cohen (1998) criteria:

Table 2. Interpretation effect size

Effect size	Interpretation
d < 0.2	Very small
0.2 ≤ d < 0.5	Small
0.5 ≤ d < 0.8	Medium
0.8 ≤ d < 1.0	Big
d ≥ 1.0	Very large

RESULTS AND DISCUSSION

Module validation analysis

The module developed in this research is the first basic physic practice module. This module has been validated by 4 expert lecturers working in education. The result of the evaluation of the first basic physics practice module prisented in Figure 1.
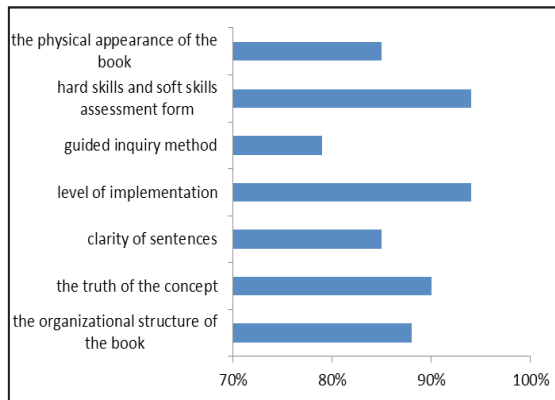
Figure 1. Result of validator's evaluation of the first basic physic practice module

Based on Figure 1 above it appears that the average percentage of the first basic physics practice module based on guided inquiry is 88%. This indicates that the overall module of this practical guide has been significant to be used as a guideline for students and lecturers in practicing the first basic physic practice. However there are some aspects that need to be improved in the steps of guided inquiry method.

Analysis of hard skills and soft skills improvement of students

Pretest and posttest results data of hard skills and soft skills achieved by students can be described statistically as shown in Table 3.

Table 3. Descriptive statistics pretest-posttest mean hard skills and soft skills of students

Descriptive Statistics					
	N	Min	Max	Mean	Std. Deviation
pretest_hardskills	24	3.0	3.9	3.346	.1911
pretest_softskills	24	3.6	4.1	3.804	.1628
posttest_hardskills	24	3.5	4.7	4.012	.3207
posttest_softskills	24	4.0	4.7	4.354	.1693

In Table 3 it appears that the average pretest score in hard skills has a minimum value of 3.0 and a maximum of 3.9 while the mean value obtained is 3.3. This shows that the av-erage score of pretest student hard skills is in pretty good category. While the soft skills have a minimum value of 3,6 and a maximum of 4,1 with a mean of ,8. This shows that the average value of pretest soft skills is in good category. For a minimum average posttest score of hard skills is 3,5 and a maximum of 4.7 with an average value of 4,0. This shows that the average value of posttest hard skills is in $3.4 \leq$ good < 4.2 category. As for the minimum score average student skill is 4.0 with a maximum of 4.7 and an average value of 4.4. This indicates that on the posttest the students' soft skill score is in the $4.2 \leq$ excellent ≤ 5.0 category.

Table 3 shows the differences in student hard skills and soft skills during pretest and posttest. Where at posttest value hard skills and soft skills of student is higher than with pretest mean value. Meanwhile, to know the category of increasing the average score of hard skills and soft skills of students can be seen in Table 4 and Table 5. While improving hard skills and soft skills can be seen in Figure 2.

Table 4. The average score of students' hard skills

Pre	Post	<g>	No	Pre	Post	<g>
3.0	3.8	0.47	13	3.3	3.8	0.36
3.3	3.9	0.43	14	3.4	4.7	1.00
3.1	3.7	0.38	15	3.3	4.2	0.64
3.9	4.7	1.00	16	3.3	3.8	0.36
3.4	4.0	0.46	17	3.2	3.6	0.27
3.5	3.9	0.33	18	3.4	4.4	0.77
3.6	3.9	0.27	19	3.3	4.0	0.50
3.6	4.3	0.64	20	3.3	4.0	0.50
3.4	4.0	0.46	21	3.4	4.4	0.77
3.4	3.9	0.38	22	3.2	3.5	0.20
3.0	3.6	0.35	23	3.3	4.2	0.64
3.4	3.8	0.31	24	3.3	4.2	0.64
The average score of hard skills				3.3	4.0	0.49

Based on Table 4 it appears that there are 4 students have hard skills improvement which high category that has value (<g>)> 0.70 while the other 20 students have hard skills increase which is being with hard skills increase in classical reach 0.49 which is categorized moderate $(0.30 \leq$ <g> $\leq 0.70)$. This indicates that the first basic physic practice based on guided inquiry can improve the hard skills of prospective physics teacher.

Table 5. The average score of students' soft skills

Pre	Post	<g>	No	Pre	Post	<g>
3.6	4.2	0.55	13	3.8	4.2	0.44
3.9	4.3	0.50	14	3.6	4.7	1.00
3.8	4.3	0.56	15	3.8	4.3	0.56
4.1	4.7	1.00	16	3.6	4.0	0.36
4.0	4.4	0.57	17	3.8	4.2	0.44
3.9	4.2	0.38	18	3.7	4.5	0.80
4.1	4.4	0.50	19	3.8	4.2	0.44
4.1	4.4	0.50	20	3.7	4.3	0.60
3.8	4.3	0.56	21	3.6	4.5	0.82
3.7	4.4	0.70	22	3.8	4.3	0.56
4.0	4.4	0.57	23	3.6	4.5	0.82
3.7	4.2	0.50	24	3.8	4.6	0.89
The Average score of Soft skills				3.8	4.35	0.61
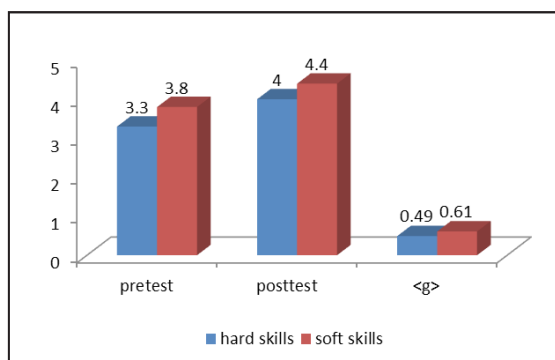
Figure 2. Graphic of the score hard skills and soft skills

This result is in line with the results of Thornton (2005) that in scientific work colleges developed through guided inquiry-based laboratory activities that provide problems to students, lead students to think and to solve the problems given. Scientific work developed through basic physics laboratory activity. In this study have four basic competence standards that are planning research activities, conducting scientific research, communicating the results of scientific research in the form of reports, and being scientific (Depdiknas, 2003).

The same thing is also put forward by Massialas in Matthew & Kenneth (2013) which states that the guided inquiry model is a teaching model that allows students to move step by step from identifying problems, defining hypotheses, formulating problems, collecting data, verifying results, and generalizing conclusions.

The improvement in student soft skills is shown in Table 5. The increase in soft skills is high category (g> 70) there are 6 students and in the moderate category ($0.30 \leq g \leq 70$) there are 18 students. The overall increase in soft skills reached 0.61 in the medium category. This shows that the first basic physics practice module based on guided inquiry can improve the soft skills of prospective physics teacher.

Based on Figure 2 above it appears that there is an improvement in hard skills and soft skills of students who each of 0.49 and 0.61 are categorized as being. Although the increase obtained is still in the moderate category, it can be concluded that the use of the first basic physic practice module based on guided inquiry can improve hard skills and soft skills of prospective physics teacher.

This is consistent with statement of Gulo (2002) that the process of inquiry learning models not only develops intellectual ability but all of the potential that exists including emotional development and skills. A similar opinion is also expressed by Sulistyorini (2007) that science learning should be conducted in scientific inquiry to cultivate the ability to think, work and be scientific and communicate it as an important aspect of life skills.

The average values of each hard skill attribute and soft skills was presented in Figures 3 and 4.
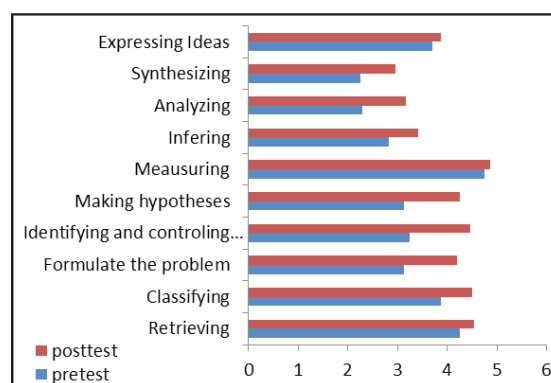
Figure 3. The improvement of hard skills

Based on Figure 3, it appears that pretest of student hard skills in inferencing, analyzing and synthesizing the data of the research results are still in sufficient category ($1.8 \leq$ Poorly < 2.6) This is because students are still confused by what they will do with the data they have obtained. In Figure 4 it is apparent that the average value of students' pretest soft skills on attribute decision making has the lowest value, this is because students have difficulties in analyzing and synthesizing the result data.
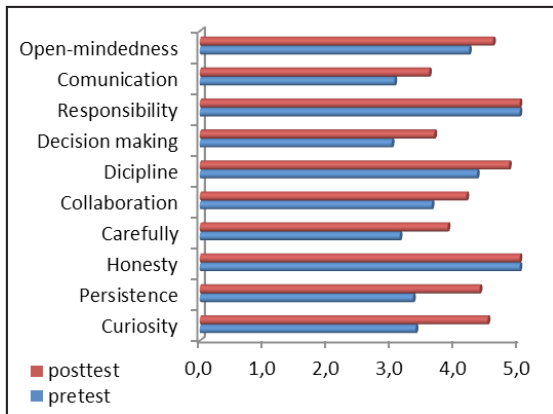
Figure 4. The improvement of soft skills

This is in accordance with the findings, (Trundle, Atwood, Christopher, & Sackes, 2010), (Brickman, Hallar, Gormally, & Armstrong, 2009) (Zawadski, 2009) and (Minderhout & Loertscher, 2007), that students at the beginning of learning did not enjoy guided inquiry-based learning because many of the activities they had to do themselves although at the same time, students' abilities grow and are able to build their own knowledge. While in the formulation of hypothesis students get good criteria, this is because students feel confuse in identifying variables and formulating research problems in accordance with the problems given by lecturers. This is supported by the research of Syafitri (2010) which states that formulating a problem with a background of hypotheses requires a basic knowledge of what is being studied.

Analysis of the effectiveness of the first basic physic practice module on hard skills and soft skills of students

Analysis of the effectiveness of the first basic physics practice module based on guided inquiry was presented in Table 6.

Tabel 6. Test of effectiveness

	Mean	Standart-Deviasi
Pretest hard skill	3.3	.1911
Posttest hard skill	4.0	.3207
Pretest soft skills	3.8	.1628
Posttest soft skill	4.4	.1693
ES (*Effect Size*) hard skills	2.65	
ES (*Effect Size*) soft skills	3.61	

Based on Table 6 it appears that ES (Effect Size) for the use of guided in the first basic physics module based on guided inquiry to hard skill and soft skill are 2.65 and 3.61 his shows that the use of the first basic physics module is very effective in improving the hard skills and soft skills of physics education students.

The high influence of the use of the first basic physics module to the improvement of hard skills and soft skills of students because the module is based on the guided inquiry syntax, where the self-planned activities of the students provide direct experience and train students' scientific work skills, starting from formulating problems, hypotheses, practical variables and operational definitions, communicate data, analyze data and make conclusions. The first basic physics practice module can help to use basic memories and transfers to new learning situations so that students can understand better basic concepts.

According to Sukmadinata (2013) stated that a meaningful module for students is presented in a form appropriate to students' level of thinking ability, and delivered in an interesting and interactive form that makes students more actively involved in the learning process, thereby generating motivation to learn more long-term students. Maretasari, Subali & Hartono (2012) in his research, stated that learning using laboratory based inquiry model has a positive and significant influence on students 'learning outcomes and students' scientific attitude. The result of research from Mokaromah (2008) in Handayani, Farida, & Anhar (2014) also stated that the development of guidebook of chemistry class chemistry of X class inquired based on inquiry is able to improve students' scientific thinking ability and appropriate to be used as instructional media.

The improvement of student hard skills in this study is moderate. This is because there are still students who have difficulty in expressing the right reasons to answer the problems in the hypothesis column, difficulty in suggesting inference, analyzing and synthesizing the result data of the lab. There are still many students who ask for lecturers or co-ass to answer the problems in the hypothetical column, formulate inference, analyze and synthesize the results of the lab data. To overcome it required repeated exercise to familiarize students doing scientific work.

The same opinion is expressed by Rustaman (2005) which stated that guided inquiry ability can influence the development of student's knowledge. Familiarize students learn through the process of scientific work, in

addition to train details of scientific skills and systematic work, can also form students' scientific thinking patterns.

In the result of improvement of student soft skills in this research also still moderate equal to 0.61. This is because there are still students who have difficulty in cooperating with members of the group, not careful in measuring, and in making decisions are still difficult and some students felt difficult in presenting or communicating the results of practice in front of the class. To overcome these problems it requires repetitive exercise so that students are accustomed to being scientific. The results of this study are also similar to the results of research Arsih (2010) in Syamsu (2017) which also shows that students' attitudes in learning using the guided inquiry-oriented IPA learning devices included in the category very well. This means that students are able to behave scientifically during the course of learning with guided inquiry so that students indirectly have gained experience in learning.

The improvement of hard skills and soft skills also affect the mastery of the first basic physics student concept. Analyzing ability and synthesizing (hard skills) students who are initially low with a value of 2.3 have an impact on mastering the first basic physics concept for example on the subject of density. On the subject, students look for density of a solid object because the ability of analyzing and synthesizing is still low so as to make decision making and communication (soft skills) also less good and assume that the density of objects is influenced by the volume of water, as well as do not understand why volume objects equal to the volume of water transferred. But after using the first basic physics practice module based on guided inquiry improves analyzing ability, synthesizing, decision making, and communication of prospective physics teachers which also affect the mastery of the first basic physics concepts. Students have understood why the density of the immersed object is equal to the transferred and can analyze the factors that influence the results of density measurements.

CONCLUSION

In this research, we have developed the first basic physics practice module to improve hard skills and soft skills of prospective physics teacher. The results of this study shows that the the first basic physics practice module based on guided inquiry model is effective in improving significantly the hard skills and soft skills of students (physics teacher candidate).

Based on the results of the research and discussion and the benefits of this research, there are several suggestion to conduct the similar research as follows: the students should given provisions or exercises about formulating the problem, controlling the variables, making hypotheses, analyzing and synthesizing the data so that they will not have any difficulties in doing the lab work.

REFERENCES

Abrahams, Ian. (2011). *Practical Work in Secondary Science: A Minds-On Approach. Continuum International Publishing Group*. India: Replika Press Pvt Ltd.

Ariesta, R. & Supartono. (2011). Pengembangan Perangkat Perkuliahan Kegiatan Laboratorium Fisika Dasar II Berbasis Inkuiri Terbimbing untuk Meningkatkan Kerja Ilmiah Mahasiswa. *Jurnal Pendidikan Fisika Indonesia*. 7(1), 62-68.

Bilgin, Ibrahim. (2009). The Effects of Guided Inquiry Instruction Incorporating with Cooperative Learning Environment on University Students' Achievement of Acid and Bases Concepts and Attitude Toward Guided Inquiry Instruction. *Scientific Research and Essay*. 4(10), 1038-1046. Diakses dari http://www.academicjournals.org/article/article1380559513_Bilgin.pdf.

Borg, W. R. & Gall, M. D. (2003). *Educational research: an introduction (7th ed.)*. New York: Longman, Inc

Brickman, P., Hallar, B., Gormally, C., & Armstrong, N. (2009). Effect of Inquiry-based learning on Students' science literacy skill and confidence. *International journal for the scholarship of teaching and learning*. 3(2). Georgia Southern University. https://pdfs.semanticscholar.org/f7c7/d357028e4c-b43e66c245b97d558df95bf192.pdf

Budi, L. (2011). *Bahan Ajar: Satu Ukuran Profesionalisme Dosen dalam Proses Pembelajaran*. http://legowo.staff.uns.ac.id/2011/04/27/bahan-ajar-satu-ukuran-profesionalisme-dosen-dalam-proses-pembelajaran/ diakses tanggal 27 Mei 2017.

Cohen, J. (1998). *Statistictical power analysis for the behavioral science, Second Edition*. New Jersery USA: Lawrence Erlbaum Associate.

Depdiknas. (2003). *Standar Kompetensi Mata Pelajaran IPA SMP dan MA Kurikulum 2004*. Jakarta Pusat Kurikulum, Balitbang Depdiknas.

Hake, Richard R. (1999). *Analyzing Change/Gain Score*. Diakses dari http://www.physics.indiana.edu/~sdi/AnalyzingChange-Gain.pdf

pada tanggal 2 Oktober 2017

Handayani, L.P., Farida F & Anhar, Azwir. (2014). Pengembangan Buku Penuntun Praktikum IPA Berbasis Inkuiri Terbimbing Untuk SMP Kelas VII Semester II. Vol. 1 No 3, 69-76. *http://ejournal.unp.ac.id/index.php/kolabora-tif/article/view/4939/3892* diakses pada Tanggal 27 Mei 2017

Gulo, W. (2002). *Strategi Belajar Mengajar*. Jakarta: PT Grasindo.

Maretasari, E., Subali, B dan Hartono. (2012). Penerapan Model Pembelajaran Inkuiri Terbimbing Berbasis Laboratorium untuk Meningkatkan Hasil Belajar dan Sikap Ilmiah Siswa. *Unnes Physics Education Journal*. 3(1): 99-105.

Matthew, M. B., & Kenneth, I. O. (2013). A Study On The Effects Of Guided Inquiry Teaching Method On Students Achievement In Logic. *The International Research Journal*. 2(1): 133-140. http://iresearcher.org/133-140%20 BAKKE%20M.MATTHEW%20gambia.pdf diakses pada Tanggal 4 Juni 2017

Minderhout & Loertscher. (2007). Lecture-free biochemistry a process oriented guided inquiry approach. *Biochemistry And Molecular Biology Education*. 35(3), 172–180. http://onlineli-brary.wiley.com/doi/10.1002/bmb.39/epdf diakses pada Tanggal 4 Juni 2017.

Nengsi, Sri. (2016). Pengembangan Penuntun Praktikum Biologi Umum Berbasis Inkuiri Terbimbing Mahasiswa Biologi STKIP Payakumbuh. *Jurnal Ipteks Terapan Research of Applied Science and Education* 10(1),(47-55). http://dx.doi.org/10.22216/jit.2016.v10i1.343

Nurussaniah., Nurhayati. (2016). Pengembangan Penuntun Praktikum Fisika Dasar 1 Berbasis Guided Inquiry Untuk Meningkatkan Kemampuan Berpikir Kritis Mahasiswa. *Seminar Nasional Fisika (SNF)* hal 63-68. Prodi Pendidikan Fisika dan Fisika, Fakultas MIPA, Universitas Negeri Jakarta

Purwaningsih, Y. I. (2014). Pengembangan Petunjuk Praktikum Biologi Ilustratif Berbasis Pendekatan Inkuiri Terbimbing (guanded inkuiri) yang Mengembangkan Pendidikan Karakter pada Materi Pokok SIstem Pencernaan Makanan untuk Kelas XI Semester 1 di SMA Muhamadiyah3 Yogyakarta. Skripsi tidak diterbitkan. Yogyakarta. Diakses di http://digilib.uin-suka.ac.id/10946/32/BAB%20 I%2C%20V%2C%20DAFTAR%20PUSTA-KA.pdf pada Tanggal 27 Agustus 2017.

Riduwan. (2008). *Metode dan Teknik Menyusun Tesis.* Bandung: Alfabeta.

Rosima, P., & Melati, I. (2012). Implementing Practical Skills In A Distance Learning of Agribusiness Study Program At Universitas Terbuka. *Jurnal Pendidikan Terbuka dan Jarak Jauh*. 13(1), 35 – 42. http://jurnal.ut.ac.id/JPTJJ/article/view/175/169. (diakses pada tanggal 2 Agustus 2017)

Rustaman, N.Y. (2005). *Strategi Belajar Mengajar IPA*. Malang: UM Press.

Schreiber, J. B. (2011). *Educational Research: Interelationship of Questions, Sampling, Design, and Analysis*. USA: John Wiley & Sons, INC.

Sukmadinata, N. S. (2013). *Pengembangan Kurikulum: Teori dan Praktek.* Bandung: Remaja Rosdakarya.

Sulistyorini, Sri. (2007). Pembelajaran IPA Sekolah Dasar. Semarang: Tiara Wacana

Syafitri, Winda. (2010). Analisis Keterampilan Proses Sains Siswa Melalui Pendekatan Inkuiri Pada Konsep Sistem Koloid. *Skripsi.* Jakarta: Fakultas Tarbiyah Dan Keguruan UIN Syarif Hidayatullah. Diakses dari http://repository.uinjkt.ac.id/dspace/bitstream/123456789/3858/1/WINDA%20 SYAFITRI-FITK.pdf pada Tanggal 27 Agustus 2017

Syamsu, D. Fetro. (2017). Pengembangan Penuntun Praktikum IPA Berbasis Inkuiri Terbimbing Untuk Siswa SMP Siswa Kelas VII Semester Genap. *BIOnatural*. 4 (2), 13-27. http://ejournal.stkipbbm.ac.id/index.php/bio/article/view/278/234 diakses pada Tanggal 2 Oktober 2017.

Thornton, S. J. (2005). *Teaching social studies that matters: Curriculum for active learning.* New York, NY: Teachers College Press.

Trianto. (2007). *Model-model Pembelajaran Inovatif Berorientasi Konstruktivistik*. Surabaya: Prestasi Pustaka.

Trundle, K. C., Atwood, R. K., Christopher, J. E., & Sackes, M. (2010). The Effect of Guided Inquiry-Based Instruction on Middle School Students' Understanding of Lunar Concepts. *Res Sci Educ*. 40:451–478. https://www.researchgate.net/publication/225793408_The_Effect_of_Guided_Inquiry-Based_Instruction_on_Middle_School_Students%27_Understanding_of_Lunar_Concepts diakses Tanggal 27 Mei 2017

Zawadzki. (2009). Is process-oriented guided-inquiry learning (POGIL) suitable as a teaching method in Thailand's higher education? Asian Journal on Education and Learning. Thailand. As. *J. Education* 2010, 1(2), 66-74. https://id.scribd.com/document/330502049/Is-Process-Oriented-Guided-Inquiry-Learning-Pogil-Suitable-as-a-Teaching-Method-in-Thailands-Higher-Education. (Diakses 2 September 2017)

PRE-SERVICE PHYSICS TEACHERS' KNOWLEDGE, DECISION MAKING, AND SELF-SYSTEM TOWARD ENERGY CONSERVATION

M. Yusup[1]*, A. Setiawan[2], N.Y. Rustaman[2], I. Kaniawati[2]

[1]Physics Education Study Program, Mathematics and Natural Sciences Education Department,
Faculty of Teacher Training and Education, Universitas Sriwijaya, Indonesia
[2]Graduate School, Universitas Pendidikan Indonesia

ABSTRACT

Along with the increase of world's energy need in one hand and of the impact of its uses in the other hand, conservation is indispensable. This paper describes pre-service physics teachers' knowledge about energy conservation, how they use their knowledge to make energy-related decisions, and how their self-system toward energy conservation. The data presented here are from selected items of a field test of instrument intended to measure energy literacy that involved 123 pre-service physics teachers from three state universities in Indonesia. They are one state university in South Sumatera and two state universities in West Java. Data from this survey study were analyzed qualitatively. Results showed that pre-service physics teachers were still lack of knowledge and knowledge utilization to make energy-related decision. However, they showed a tendency to engage in energy conservation efforts.

ABSTRAK

Seiring meningkatnya kebutuhan energi dunia di satu sisi dan dampak penggunaannya di sisi lain, konservasi menjadi sangat penting. Artikel ini menggambarkan pengetahuan mahasiswa calon guru fisika tentang konservasi energi, bagaimana mereka menggunakan pengetahuan tersebut untuk mengambil keputusan, dan bagaimana self-system mereka terkait konservasi energi. Data diperoleh dari uji lapangan terhadap instrumen yang ditujukan untuk mengukur literasi energi yang melibatkan 123 mahasiswa calon guru fisika dari tiga perguruan tinggi negeri di Indonesia. Ketiga universitas negeri tersebut adalah satu berada di Sumatera Selatan, dan dua berada di Jawa Barat. Data dari penelitan survey ini dianalisis secara kualitatif. Hasil analisis menunjukkan mahasiswa calon guru fisika kurang dalam pengetahuan dan penggunaan pengetahuan untuk membuat keputusan terkait energi. Namun demikian, mereka menunjukkan kecenderungan untuk terlibat dalam upaya konservasi energi.

Keywords: Energy Conservation; Decision Making; Pre-Service Physics Teacher; Self-System

INTRODUCTION

Along with the increase of energy needs on the one hand and the effects of its uses in other hand, conservation is deemed to be the solution. The term energy conservation can indeed have two interpretations. Firstly, energy conservation, in physics, means that energy is conserve or is known as principle of conservation of energy. Energy is neither created nor destroyed. This meaning appears to be opposed

to the second meaning, that energy conservation is interpreted in everyday language as energy saving. Regarding to energy saving, it can be done in two ways, technology development (efficiency) and behavioral change.

Development of technology to improve efficiency is necessary, but it is not sufficient to reduce the energy consumption (Costanzo, Archer, Aronson, & Pettigrew, 1986). The development of technology will has more impacts if it is supported by the changes of human behavior in using energy. Behavioral changes will occur if a person has sufficient knowledge (Finger, 1994; Frick, Kaiser, & Wilson, 2004; Jen-

*Correspondence Address:
Jalan Palembang-Prabumulih Km 32 Indralaya,
Ogan Ilir 30665 Sumatera Selatan, Indonesia
E-mail: m_yusup@fkip.unsri.ac.id

sen, 2002; Kaiser & Fuhrer, 2003; Zografakis, Menegaki, & Tsagarakis, 2008) and the attitude or affect (Davis, 1985; Dewaters & Powers, 2011; Gomez-Granell & Cervera-March, 1993; Lee, Lee, Altschuld, & Pan, 2015; Vlahov & Treagust, 1988). A such characteristic of individual is called as an energy literate person (Barrow & Morrisey, 1989; DeWaters & Powers, 2013).

Without a basic knowledge of physics the ideas around energy conservation are likely meaningless (Newborough, Getvoldsen, Probert, & Page, 1991). System knowledge, action-related knowledge, and effectiveness knowledge are regarded as conservation-relevant knowledge (Frick et al., 2004). System knowledge relates to knowledge about energy problems. This is a basic scientific knowledge. Action-related knowledge relates to how to conserve energy. To select among alternatives which is more effective way to conserve energy, then someone needs effectiveness knowledge.

When someone select between two or more alternatives that initially appear equal, the process of decision making is used (Baron & Brown, 1991; Marzano & Kendall, 2007). Informed decisions regarding energy issues faced in everyday life constitute process of someone utilize his/her knowledge. However, in making decision, someone may use normative (rational) or naturalistic approach (Jonassen, 2012). With rational perspective, decisions are made by considering the one that provides maximum utility, while with naturalistic perspective, decisions are made by considering the one that is most consonant with personal beliefs (Jonassen, 2012).

Interconnected attitudes, emotions, and personal beliefs shape individual self-system (Marzano & Kendall, 2007). Further, Marzano & Kendall (2007) proposed four type of self-system. They are examining importance, examining efficacy, examining emotional response, and examining motivation.

This paper aims to describe the measurement results of pre-service physics teachers related to energy conservation. Questions that will be answered in this paper are: (1) what is the pre-service physics teachers' knowledge regarding energy conservation; (2) how do pre-service physics teachers make decisions related to energy conservation; and (3) what is *the self-system* of pre-service physics teachers toward energy conservation.

METHOD

The data reported on here resulted from selected items according to the topics of energy conservation of the instrument that purported to measure pre-service physics teachers' energy literacy. The instrument was developed based on previous work (Yusup, Setiawan, Rustaman, & Kaniawati, 2017). For our purpose in this paper, we relabeled the code of items from its original version. There were 123 pre-service physics teachers from three state universities in Indonesia who involved as participants. They are one state university in South Sumatera, and two state universities from West Java. The participants were from the first to third year of study in the universities. Their participation in the current study were voluntary. Descriptive method was used to analyze the data.

RESULTS AND DISCUSSION

Pre-service physics teachers comprehension toward energy conservation

Figure 1 depicts two items to assess pre-service physics teachers' comprehension of energy conservation. Question 1 conflicted pre-service physics teachers' understanding about the principle of energy conservation (energy is neither created nor destroyed) and the current consideration of conservation of energy (resources) where the world is seen as running out of energy, There were 39% of participants agreed that energy will not be exhausted and 41% of participants added the statement that although energy in the world will not be exhausted but remains vital to save energy. Only 7% of participants who could answer precisely this question.

The result indicates that the majority of pre-service physics teachers did not understand the principle of energy conservation well. They could not distinguish the concept of energy conservation and energy degradation. This can be confirmed from their answer to the Question 2 (Figure 1).

In Question 2, participants were asked to evaluate issue on depleting non-renewable energy sources. Majority of participants (92%) expressed disagreement if non-renewable energy sources were used regardless of the availability of energy sources for future generation.

The results revealed that pre-service physics teachers have not understood the concept of energy conservation well. They equated

principle of energy conservation with energy conservation in the sense of energy saving. These findings are consistent with previous studies (Kesidou & Duit, 1993; Papadouris, Hadjigeorgiou, & Constantinou, 2014). This weakness is due to the use of the term energy in everyday life are not in accordance with the conception of physics (Duit, 1981; Kesidou & Duit, 1993). Another cause is the lack of recognition of the concept of energy degradation in learning (Daane, Vokos, & Scherr, 2014; Goldring & Osborne, 1994; Pinto, Couso, & Gutierrez, 2004).

Question 1
Based on his understanding of the law of conservation of energy, a student argues that energy in this world will not be exhausted. Therefore, according to him, we do not need to save energy. What will be the consequences if the student's opinion is followed? Explain your reason.

Question 2
Although our petroleum and natural gas reserves are getting lesser, it does not matter that we use as much petroleum and natural gas as we need now because future generation will have new energy that we do not have today.
Do You agree with this statement? Explain your reason.

Figure 1. Items to assess pre-service physics teachers comprehension toward energy conservation.

Pre-service physics teachers' energy-related decision making regarding effectiveness knowledge

Two questions in Figure 2 were intended to assess how pre-service physics teachers use their knowledge to make energy-related decision. Question 3 provides a condition in which the available alternatives of *incandescent light bulb* (ILB), *compact fluorescent light* (CFL), and *light emitting diodes* (LED) bulbs for purchase. Sensible option is to buy products that are more economical and less impact on the environment and the choice should be LED bulb.

The decision-making tendency to consider only one aspect was confirmed by pre-service physics teachers' responses to Question 4 (Figure 2). A total of 56% of participants chose the product only on the basis of the electric power consumption or of the price aspect. Only 4% of participants chose product with comprehensive consideration, which was more beneficially from economical and environmental aspects.

Question 3
The power consumption, lifetime, and price of the ILB, CFL, and LED bulb with the 800 lumens light output in the table below.

Type	Power (watt)	Life-time (hours)	Price (IDR)
ILB	60	1 000	8.000
CFL	14	8 000	38.000
LED	10	25 000	88.000

If you have Rp 90,000 to buy bulb(s), which bulb(s) will you buy? Explain the reasons for your choice?

Question 4
One day your father asked your help to accompany him to buy in cash an air conditioner (AC) to be installed in one room in your house with installed power is 2 200 watts. He tells you that his budget is a maximum of Rp 3,000,000,00. Apparently, in the store there are available products with different power prices and power consumption. All products are warranted one year for indoor unit and three year warranty for outdoor unit (compressor).Product specifications as shown in the table below. Your father only receive the price up to Rp 3,000,000,00. Apparently, in the store there are available products with different prices and power consumption. All products are warranted one year for indoor unit and three years warranty for outdoor unit (compressor). Product specifications are as in the table below.

Brand	Power (watt)	Price (IDR)	Compressor material	Dimension of indoor unit (cm)
A	795	2.900.000	Fiber	100x30x25
B	840	2.700.000	Fiber	88x30x23
C	900	2.600.000	Zinc	87x29x22
D	925	2.500.000	Zinc	77x24x18

Which brand of AC product do you recommend to buy?

Figure 2. Items to assess pre-service physics teachers' energy-related decision making regarding effectiveness knowledge.

Pre-service physics teachers' energy-related decision making regarding action-related knowledge

When challenged with a situation that requires taking action, pre-service physics teachers did not use action-related knowledge well. Question 5 (Figure 3) illustrates the situation of someone leaving home (to go to campus) using a motorcycle then realizing that he left light bulbs still on. The choice to be taken is to go back immediately and turn the lights off or continue to go to campus. A total of 74% of participants are not able to answer the question and only 9% were able to answer comprehensively. The majority of the answers were with no an appropriate argument and so were identified as guessed answers, such as, "I will go back," or "I will continue to go to campus."

The lack of knowledge utilization to make energy-related decision of pre-service physics teachers was confirmed from responses of Question 6. The situation was when finished watching television, what they do to the televi-

sion. The action could be considered as habitual. The response from participants showed that only 21% who stated that they turn the television off and disconnect the plug from the electric terminal. The rest of participants prefer to turn the television off but let it in standby mode (the power cable remain plug in electric terminal). Even a few of participants stated they let the television on.

Question 5

One day when you ride your motorcycle to go to campus, you suddenly remember that you had not turned the bulbs off that totaly use 100 W of power consumption. With only consider of CO_2 emitted, would you go back to turn bulbs off or continue to go to campus?

Use the following assumption:
- If you do not come back now there is an additional time the lights will be on for 8 hours until you get home from campus.
- The bulbs have an emission intensity of 0.6 kg CO_2/ kWh.
- If you back home, you will travel a total distance of 5 km (back and forth) and your motorcycle gasoline consumption is 50 km/liter, with an emission factor of 3.2 kg CO_2/liter of gasoline.

Ignore the CO_2 emitted by the bulbs during the time you need to get home if you decide to go back.

Figure 3. Item to assess pre-service physics teachers' energy-related decision making regarding action-related knowledge.

In making decision toward energy, pre-service physics teachers tend to consider only one aspect, especially the economic aspect. They tended to use rational perspective (Jonassen, 2012). Indeed, cost factors, or the ratio of personal costs and ecological benefits (Kaiser & Fuhrer, 2003), can be considered in making decision. Pre-service physics teachers did not showed an integrated or comprehensive approach (Liu, Gupta, Springer, & Wagener, 2008 in making decision. The effectiveness and action-related knowledge (Kaiser & Fuhrer, 2003) should be required to make decisions related to energy conservation.

Pre-service physics teachers' self system toward energy conservation

Items related to *self-system* include *self-efficacy,* emotional response, and motivation. To examine the *efficacy* of pre-service physics teacher in conserving energy, the question asked whether they believe that they can use energy efficiently. A total of 54% participants believed they could use energy efficiently, while the rest stated they were not sure. Generally, the reason of those who were not sure because they did not know how to reduce their con-

sumption of energy.

The proportion of efficacy responses was the same as the answers of the question of whether they have a motivation to teach students to save energy. There were 54% of participants expressed their wish and were confident to do so, while the rest expressed their wish but were not sure they could.

Emotional response of pre-service physics teacher related to energy use were tested by asking a question that illustrate a situation when at noon someone found in one of the empty lecture room the light bulbs are left on. The majority of participants (75%) expressed emotions that reflect the attitude of energy saving. Among the feelings that they were annoyed or deplore see a situation where the energy is used unwisely (wasteful). A little percentage of participants (25%) felt that it was prevalent situation so that was nothing wrong.

The answers of question to examine motivation were similar proportion to the emotional responses question. Pre-service physics teachers were asked whether it is important or not to teach energy conservation to students at school. A total of 78% of participants stated that energy conservation attitude was an important competency to be taught at school.

Self-system determines whether a person will be involved in a program or not (Marzano & Kendall, 2007). The results showed that the majority of pre-service physics teachers had motivation to engage in energy conservation, but only half of those who had confidence to do so. Although in different topic, Rokhmah, Sunarno, & Masykuri's (2017) finding about the lack of disposition in some textbooks they used in high school, can be suspected as the cause of the low of pre-service physics teachers' efficacy. Nevertheless, pre-service physics teachers expressed emotional responses that showed a tendency to conserve energy.

CONCLUSION

Energy conservation principle is often confused with the everyday life that associate with the energy saving. Unfortunately, the majority of pre-service physics teachers have not had a proper understanding of the concepts. At the level of knowledge utilization to make energy-related decisions, pre-service physics teachers also showed low performance. Although the majority of pre-service physics teachers stated that energy conservation is important competency and they showed their

motivation to involve in such efforts, but they were still lack of efficacy.

REFERENCES

Baron, J., & Brown, R. V. (1991). *Teaching decision making to adolescents*. Mahwah, New Jersey: Lawrence Erlbaum.

Barrow, L. H., & Morrisey, J. T. (1989). Energy literacy of ninth-grade students: A comparison between Maine and New Brunswick. *The Journal of Environmental Education*, *20*(2), 22–25.

Costanzo, M., Archer, D., Aronson, E., & Pettigrew, T. (1986). Energy conservation behavior: The difficult path from information to action. *American Psychologist*, *41*(5), 521–528.

Daane, A. R., Vokos, S., & Scherr, R. E. (2014). Goals for teacher learning about energy degradation and usefulness. *Physical Review Special Topics - Physics Education Research*, *10*(20111), 1–16.

Davis, P. (1985). The attitude and knowledge of Tasmanian secondary students towards energy conservation and the environment. *Research in Science Education*, *15*, 68–75.

Dewaters, J. E., & Powers, S. E. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy*, *39*(3), 1699–1710.

DeWaters, J., & Powers, S. (2013). Establishing measurement criteria for an energy literacy questionnaire. *The Journal of Environmental Education*, *44*(1), 38–55.

Duit, R. (1981). Energy as a conserved quantity— remarks on the article by R.U. Sexl. *European Journal of Science Education*, *3*(3), 291–301.

Finger, M. (1994). From knowledge to action? Exploring the relationships between environmental experiences, learning, and behavior. *Journal of Social Issues*.

Frick, J., Kaiser, F. G., & Wilson, M. (2004). Environmental knowledge and conservation behavior : exploring prevalence and structure in a representative sample. *Personaliity and Individual Differences*, *37*, 1597–1613. http://doi.org/10.1016/j.paid.2004.02.015

Goldring, H., & Osborne, J. (1994). Students' difficulties with energy and related concepts. *Physics Education*, *29*, 26–31.

Gomez-Granell, C., & Cervera-March, S. (1993). Development of conceptual knowledge and attitudes about energy and the environment. *International Journal of Science Education*, *15*(December 2014), 553–565.

Jensen, B. B. (2002). Knowledge, action and pro-environmental behaviour. *Environmental Education Research*, *8*(3), 325–334.

Jonassen, D. H. (2012). Designing for decision making. *Educational Technology Research and Development*, *60*(2), 341–359. http://doi.org/10.1007/s11423-011-9230-5

Kaiser, F. G., & Fuhrer, U. (2003). Ecological behavior's dependency on different forms of knowledge. *Applied Psychology: An International Reviiew*, *52*(4), 598–613.

Kesidou, S., & Duit, R. (1993). Students' conceptions of the second law of thermodynamics--an interpretive Study. *Journal of Research in Science Teaching*, *30*(1), 85–106.

Lee, L. S., Lee, Y. F., Altschuld, J. W., & Pan, Y. J. (2015). Energy literacy: Evaluating knowledge, affect, and behavior of students in Taiwan. *Energy Policy*, *76*, 98–106.

Liu, Y., Gupta, H., Springer, E., & Wagener, T. (2008). Linking science with environmental decision making: Experiences from an integrated modeling approach to supporting sustainable water resources management. *Environmental Modelling & Software*, *23*, 846–858.

Marzano, R. J., & Kendall, J. S. (2007). *The new taxonomy of educational objectives* (Ed. Kedua). Thousand Oaks, California: Corwin Press.

Newborough, M., Getvoldsen, P., Probert, D., & Page, P. (1991). Primary- and secondary-level energy education in the UK. *Applied Energy*, *40*, 119–156.

Papadouris, N., Hadjigeorgiou, A., & Constantinou, C. P. (2014). Pre-service elementary school teachers' ability to account for the operation of simple physical systems using the energy conservation law. *Journal of Science Teacher Education*, *25*, 911–933.

Pinto, R., Couso, D., & Gutierrez, R. (2004). Using research on teachers' transformations of innovations to inform teacher education. The case of energy degradation. *Science Education*, *89*(1), 38–55.

Rokhmah, A., Sunarno, W., & Masykuri, M. (2017). Science literacy indicators in optical instruments of highschool physics textbooks chapter. *Jurnal Pendidikan Fisika Indonesia*, *13*(1), 19–24.

Vlahov, S. J., & Treagust, D. F. (1988). Students knowledge of energy and attitudes to energy conservation. *School Science and Mathematics*, *88*(6), 452–458.

Yusup, M., Setiawan, A., Rustaman, N. Y., & Kaniawati, I. (2017). Developing a framework for the assessment of pre-service physics teachers' energy literacy. *Journal of Physics: Conference Series*, *877*, 12014.

Zografakis, N., Menegaki, A. N., & Tsagarakis, K. P. (2008). Effective education for energy efficiency. *Energy Policy*, *36*, 3226–3232.

THE INFLUENCE OF CAUSAL THINKING WITH SCAFFOLDING TYPE 2A AND 2B ON OPTICS PROBLEM-SOLVING ABILITY

N. Nurmadiah, J. Rokhmat*, S. Ayub

[1]Study Program of Physics Education, FKIP Universitas Mataram, Indonesia

ABSTRACT

The effectiveness of learning is affected by the assistance stages (scaffolding) provided. For example, the scaffolding of type 2a and type 2b supports the causal-thinking approach in learning. The type 2a informs the causal model, number of causes and effect, while 2b informs its argument sample. This research aimed to identify the effect of causal thinking process (CTP) with scaffolding type 2a and 2b on optics problem-solving ability (PSA) of students. The type of the research was quasi-experiment with the non-equivalent-group design. Data were obtained with PSA-test and analyzed with the two-tail test with separated variance formula at significance degree of 5% to determine the effect of each type of the CTP on the PSA, also to determine its difference. The results showed that t_{count} for each of the first two t-tests were greater than t_{table}, but t_{count} for the third one was smaller than its t_{table}. This research concluded that the implementation of the CTP with the scaffolding of type-2a and 2b were effective to improve the student's PSA. However, the improvements were not different.

ABSTRAK

Efektivitas pembelajaran dipengaruhi bantuan tahapan (*scaffolding*) yang diberikan. Dengan pendekatan berpikir kausalitik ini, diperkenalkan *scaffolding* tipe-2a dan tipe-2b. Kedua *scaffolding* ini menginformasikan model kausal serta jumlah Cause dan Effect tetapi pada tipe-2b ditambah contoh argumentasinya. Penelitian ini bertujuan mengidentifikasi pengaruh proses-berpikir-kausalitik (PBK) ber-*scaffolding* tipe-2a dan tipe-2b terhadap kemampuan-pemecahan-masalah (KPM) optik siswa. Jenis penelitian kuasi-eksperimen dengan desain *non-equivalent-group*. Data diambil menggunakan alat tes-KPM dan dianalisis dengan uji-t dua pihak menggunakan rumus *separated varians* pada signifikansi 5% untuk mengetahui pengaruh PBK tipe-2a dan 2b terhadap KPM, serta perbedaan kedua pengaruh tersebut. Hasil menunjukkan nilai t_{hitung} untuk dua uji-t pertama lebih besar dari t_{Table} terkait tetapi nilai t_{hitung} untuk uji ketiga adalah lebih kecil dari t_{Table}-nya. Simpulan penelitian implementasi PBK ber-*scaffolding* tipe-2a dan 2b masing-masing berpengaruh terhadap peningkatan KPM siswa tetapi kedua pengaruh tersebut tidak berbeda.

Keywords: Causal; Problem-Solving, Scaffolding, Optics

INTRODUCTION

Science does not only covers the activities of reading, remembering, or storytelling; but also encourages people to use their skills to solve problems in the actual world, such as creating, building, and developing new ideas and ways of thinking. Moreover, science learning must involve the student in problem-solving activities (Barba, 1998).

Physics as a branch of natural science is critical to learning for fostering the thinking skills. Physics as a subject has the objective to develop the students' reasoning skills in thinking inductively and deductively. Students can apply concepts and principles of physics to explain various natural phenomena and to solve problems both qualitatively and quantitatively (BSNP, 2006). Therefore, it is urgent to develop a physics learning with the orientation of balancing between the provisions of material by the teacher with problem-solving practices to boost the students' thinking skills ability.

The example of the thinking processes

*Correspondence Address:
Jalan Majapahit no 62 Mataram - 83125
E-mail: joni.fkip@unram.ac.id

that can improve students' reasoning skills in problem-solving is creative thinking, critical thinking, and analytical thinking. Glaser defines critical thinking as an attitude of wanting to think deeply about problems, as well as knowledge of examination methods and logical reasoning (Fisher, 2009). Chance said that critical thinking is the ability to analyze facts, create and compile ideas, maintain opinions, make comparisons, describe conclusions, evaluate arguments and solve problems (Amer, 2005).

The analytical thinking is a component of critical thinking. This way of thinking represents the ability to scrutinize and unravel facts, and thoughts into its strengths and weaknesses such as the development of the capacity to think carefully (thoughtfully), how to discern, to solve problems, analyze data, and remember and collect information (Amer, 2005).

This study is inspired by previous research conducted by Rokhmat (2013) which implementing causal and analytical thinking processes (CATP) with a standardized pattern and proven to be able to improve the problem-solving ability of student teacher of physics. Based on the limitations of the study, the standardized CATP used was still general; therefore, one of the things that became a recommendation for other researchers was to use CATP with scaffolding. In this study, CATP refers to as a causal thinking process (CTP).

The causal thinking process is a combination of causal and analytic thinking skills. Lenzen explained that the essence of causal is the connection between two phenomena, the phenomena of the cause and the phenomena of the results (Rokhmat, Agus, & Dadi, 2012). Meanwhile, Hardy suggests that analytic thinking is the ability to think of students to describe, detail, and analyze information used to understand knowledge by using logical reason and mind, not based on feelings or guesses (Marini, 2014).

In the learning process, physical phenomena facilitate students' causal and analytical thinking abilities. Also, students are required to determine the causal components in a physical problem while they do the casual thinking. Then, students need to think deductively in predicting all events (consequences) that have the chance to occur based on the causes. When they do the analytical thinking, students must be able to identify the conditions of the causes which affect on specific event or effect based on the knowledge that has been possessed which includes concepts, principles, theories,

or related physical laws (Rokhmat et al, 2012).

The pattern of CTP with scaffolding type 2a is the development of causal and analytical thinking facilitated by the main pattern of the causal table with some part of the results have been given in the table. Then, students must determine the components of the causes and other effects with the known amount of a physical phenomenon. Also, the students need to explain how the causes can produce such an effect. Meanwhile, the pattern of CTP with scaffolding type 2b is the development of the CTP with scaffolding type 2a pattern. In this pattern, there is additional assistance information and explanations (Rokhmat, 2013). In this study, the CTP with scaffolding type 2a and 2b was modified by adding a part of the causative component to the causal table.

There are six indicators of problem-solving (IPS), namely (1) *understanding*, it means the ability to understand ideas or ideas in each question, (2) *selecting*, which explains the ability to choose or select a variety of possible consequences that will occur regarding the causes in the matter, (3) *differentiating*, the ability to distinguish and choose causes that can produce a certain effect, (4) *determining*, the ability to determine the concepts, principles, theories, and / or laws of physics to support in identifying a number of causes to produce a consequence, (5) *applying*, the ability to use concepts, principles, theories, and / or physical laws to support a identify or cause certain consequences, and (6) *identifying*, that is, identifying the causes which produce a particular effect (Rokhmat, 2013; Rokhmat, Marzuki, Hikmawati, and Verawati, 2017; Helmi, Rokhmat, and Ardhuha, 2017; Tamami, Rokhmat, and Gunada, 2017; and Yuliana, Rokhmat, and Gunada, 2017). In solving the problem, students often have the difficulties in distinguishing the causal elements as the factors of the desired answer especially if the problem states that the real cause is not a factor of the effect but as a factor of the other. With the causal thinking approach with scaffolding type 2a and 2b, students can determine the causes and effects of a problem efficiently. In both types, the number of cause and effect elements are informed, and some examples are given. Specifically for type-2b scaffolding, there are examples of arguments that explain how the conditions of each cause and its effects can occur.

This objective of this study is to identify the influence of Modified causal thinking process with scaffolding type 2a and 2b which are

facilitated by the worksheet on the development of students' problem-solving ability/PSA (H_{01} and H_{02}). Also, to identify the difference of the influence between Modified causal thinking process with scaffolding type 2a and 2b facilitated by the worksheet on the development of students' problem-solving ability/ PSA (H_{03}).

METHOD

This study employed the Quasi-Experimental with Non-equivalent Group Design as shown in Table 1. The population was all students of class XI-MIA MAN-2 Mataram. The sample was taken by purposive-sampling technique. The research subjects obtained were XI-MIA-2 students (9 boys and 23 girls) as the experimental class 1 and XI-MIA-1 students (7 boys and 25 girls) as experimental class 2.

Table 1. Non-equivalent Group Design

Group	Pre-test	Treatment	Post-test
Experimental Class 1	O_1	X_1	O_2
Experimental Class 2	O_3	X_2	O_4

(Adapted from Setyosari, 2012)

Before treatment, the pre-test was conducted in both classes. After that, the treatment was given to both classes, i.e., experimental class 1 applied a modified causal thinking process with scaffolding type 2b facilitated by worksheet (X_1); whereas the experimental class 2 employed the modified causal thinking process with scaffolding type 2a facilitated by worksheet (X_2). After treatment, post-test was performed in both classes to measure the results of the treatment. The difference between worksheet for X_1 and X_2 is the example of cause-effect which is given in the worksheet X_1, while in worksheet X_2 the example of this explanation is not given.

The independent variable in this study is the modified causal thinking process with scaffolding type 2a and 2b assisted by the worksheet; whereas the dependent variable is the students' problem-solving ability; and the control variables are material, learning objectives, assessment methods, and time allocated to both classes.

The research instrument includes the syllabus, lesson plan, and worksheet to help the modified causal thinking process with scaffolding type 2a and 2b, and students' problem-solving ability (PSA) questions. The PSA items were analyzed for its validity and reliability. Validity analysis employed the r product moment correlation equation with rough numbers, and the reliability of essay items applied the Alfa formula. The instrument test results show eight valid and reliable questions. The pre-test and post-test data were then tested for normality using the chi-square formula (χ^2), the calculation results showed that the pre-test and post-test data were normally distributed. The hypothesis test uses a two-party t-test with a separated variance formula.

The questions were prepared based on the six PSA indicators to facilitate the emergence of the indicators. First, the question should be causal with a simple combined model, which has more than one cause or effect element (having more than one answer) (Rokhmat et al, 2017b). Secondly, the questions in the problems indicate an open answer. In this case, the answer and deception are provided for students to choose from. Thirdly, there is also a demand for students to explain the cause element as the effect of answers can occur. Finally, in explaining, students need to involve concepts, principles, laws, and or related theories (Rokhmat, 2013).

RESULTS AND DISCUSSION

Results

The results of the study include the pre-test and post-test of problem-solving ability (PSA) score analysis and the results of hypothesis testing for the experimental group 1 and group 2. Students in group 1 used causal thinking process (CTP) with modified scaffolding type 2b facilitated by students' worksheet while group 2 applied the Modified CTP with scaffolding type 2a assisted by worksheet.

Stages of learning activities: the application of Modified CTP with scaffolding type 2a assisted by worksheet in learning can promote the students to learn through the following stages: 1) understanding physical phenomena, 2) completing the causal table, by a) writing down the causal elements that have not been written in the Table, b) predicting the effects that have the chance to occur that have not been written in the Table, and 3) compile arguments to explain how the conditions of each effect are related to producing the predicted results. The preparation of this argument for each effect

including those that have been written in the causal table.

Table 2. Example of the causal table with scaffolding type 2a

Causes (5)	Effects (3)
Cause-1	Effect-1
Cause-2	…………….
……………………	…………….
……………………	
……………………	

Explanation:
Effect-1:
………………………………………..

………………………………………..
Effect-2:
………………………………………..

………………………………………..
Effect-3:
………………………………………..

………………………………………...

In learning with CTP with scaffolding type 2b, students learned with the same stages as scaffolding type 2a. However, all arguments in type 2a were prepared by themselves, while in type 2b, there were some examples of references to direct the students in arranging their arguments.

Table 3. Example of the causal table with scaffolding type 2b

Causes (5)	Effects (3)
1. Cause-1	1. Effect-1
2. Cause-2	2. …………….
3. ……………………	3. …………….
4. ……………………	
5. ……………………	

Explanation:
Effect-1: The explanation of how each element of cause can give the effect 1 occurs.
Effect-2:
………………………………………..

………………………………………..
Effect-3:
………………………………………..

………………………………………...

Indicators of problem solving abilities (IPS) in learning process: The learning process applied the problem-solving ability (PSA) to students as follows (Rokhmat, 2013, Rokhmat, et al, 2017): First, students must be able to understand the purpose of the questions expressed in verbal representations together with conceptual images. Indicators of understanding are based on the ability to predict or choose the effect, whether predicted or selected is correct (at least predict or choose an effect) or lead to the requested answer (the indicator of problem-solving/IPS 1). Second, the related problems show that students can predict or choose at least 50% of the effects that are likely to occur (IPS 2). Third, the related problems show that students explained how a predictable or selected effect occurs at least 50% of the cause components as the factors in the occurrence of the effect (IPS 3). Fourth, it shows that students in explaining on how a predicted or selected effect occurs which involves at least one of the concepts, principles, theories, or physical laws associated with the problem (IPS 4). Fifth, it shows that students in explaining how a predictable or chosen effect occurs correctly using at least one of the concepts, principles, theories, or physical laws associated with the problem (IPS 5). Sixth, it shows that students in explaining how a predictable or chosen effect occurs to get a score of at least 50% of the maximum score, which is the same as the maximum score of "5" with the correct number of effects that have been predicted or selected (IPS 6).

The results of the pre-test and post-test of the Problem Solving Ability (PSA) showed that the enhancement average of PSA score was ranged between 1.62 to 1.78 times as shown in Table 2 and Table 3. It indicates that the implementation of learning with causal thinking process (CTP) with modified scaffolding type 2a and 2b assisted by students' worksheet can improve students' ability in solving physics problems.

The difference between the mean of post-test and pre-test in the experimental class 1 using Modified CTP with scaffolding type 2b facilitated by worksheet was 18.75. In order to determine the effect of this type of CTP, a separated variance t-test was performed with dk = n - 1. The calculation results show that the value of $t_{count} > t_{table}$ at 5.88 > 2.04. It indicates that H_{02} is rejected where there is an effect of modified CTP with scaffolding type 2b increased the students' problem-solving ability.

The difference between the average

Table 4. P*re-test* score of students in Experimental Class 1 and 2

Class	Number of students (N)	Max Score	Min Score	Mean	S	s^2
Exp. 1	32	48	6	24.13	10.34	106.92
Exp. 2	32	40	4	26.31	8.05	64.8

Table 5. Post-test scores of students in Experimental Class 1 and 2

Class	Number of Students (N)	Max Score	Min Score	Mean	S	s^2
Exp. 1	32	79	23	42.88	14.79	218.74
Exp. 2	32	63	21	42.69	10.15	103.02

Table 6. Percentage of the average score of p*re-test* and *post-test* of the students' problem-solving ability in Experimental Class 1 and 2

Data	Class	The average of problem-solving abilities (%)					
		IPS 1	IPS 2	IPS 3	IPS 4	IPS 5	IPS 6
Pre-test	Exp. 1	83	20	15	20	5	0.4
	Exp. 2	91	25	16	15	10	0.4
Post-test	Exp. 1	100	42	44	37	25	9
	Exp. 2	100	52	55	34	13	2

post-test and the pre-test score of experimental class 2 using Modified CTP with scaffolding type 2a assisted by the worksheet was 16.38. In order to determine the effect of CTP, a separated variance t-test was performed with dk = n - 1. The calculation results showed that the value of $t_{count} > t_{table}$ at 7.15 > 2.04. It indicates that H_{01} was rejected where there is an influence of the causal thinking process (CTP) with modified scaffolding type 2a towards increasing the students' problem-solving ability.

Moreover, the difference of the influence of the causal thinking process (CTP) with modified scaffolding type 2a and 2b assisted by the worksheet was tested using separated variance t-test. This test applied the data of post-test and pre-test score difference from both classes. The results of the test showed that the value $t_{count} < t_{Table}$ at 0.87 < 2.04; thus, H_{03} was accepted where there is no significant influence of the Modified causal thinking process with scaffolding type 2a and 2b assisted by the worksheet to the students' problem-solving ability.

The percentage of pre-test and the post-test average score of each IPS of the students in class 1 and 2 are shown in Table 6.

Discussion

From the view of the pre-test and post-test ratio, the problem-solving ability of the students was highly increased showing more than one and a half times compared to the previous ability. Moreover, specifically for students in the experimental class 1, it increases almost two times. This phenomenon, qualitatively describes the excellent effectiveness of the CTP with two types scaffolding implementation in improving students' problem solving ability including the ability to understand the problem, choose Cause and Effect aspects, differentiate Cause which is a factor of each Effect, determine concepts, principles, theories, and or the laws of physics (cptIP). Moreover, it increases the ability to implement cptIP in composing arguments and explaining why each effect occurs by involving cptIP. This finding is in line with recommendations for the development of learning instruments with a causal thinking approach with scaffolding (Rokhmat, Marzuki, Hikmawati, & Verawati (2017). Meanwhile, the effectiveness of this form of scaffolding is in line with the research of Helmi, Rokhmat, & Arhuha (2017), Tamami, Rokhmat, & Gunada (2017), Putrie (2016), and Yuliana (2016), as well as Yuliana, Rokhmat, and Gunada (2017).

From the achievement level, students' problem-solving ability was still deficient. In the beginning, the PSA of students in two classes were about 25%. These results were actually because of the PSA questions applied are classified as unusual for the students. The questions were designed with a semi-open pattern, where students can choose more than one

correct answers. Surprisingly, there are some questions with all the correct choice of answers. Moreover, students were also allowed to give additional answers, and they were needed to make arguments in explaining how the condition of each element of Cause is seen as a factor of each selected Effect, which is indicated by the answers that have been chosen. The explanation of the PSA criteria is in line with the statement of Rokhmat (2013); Rokhmat et al (2017), Helmi, et al (2017), Tamami, et al (2017) and Yuliana, et al (2017).

Final achievement of the students' problem-solving ability (PSA) as a result of the post-test: It has been stated that this students' final PSA was more than one and a half times compared to initial PSA. However, its achievement is still below 50%, and even closer to 40%. If the final achievement benchmark is set at 80% with the assumption that the average achievement of the average student is "A" and this predicate is valid for the percentage of achievement of 80% or more, then the final achievement of PSA is still half of the desired ideal achievement. This fact shows that although the CTP with scaffolding type 2a and 2b approach is effective in increasing students' PSA, even though its achievement is still far from its ideal achievement.

This fact shows at least two things, i.e., 1) CTP has been effective in increasing students' PSA, and 2) the use of PSA questions of this type along with the development of relevant CTP needs to be exposed from lower levels of education. Therefore, it is possible to achieve the final PSA for each implementation of CTP development by ideal expectations, which is 80% or more.

Initial Problem Solving Ability (PSA) based on the pre-test results for experimental class 2 on IPS 1, IPS 2, IPS 3, and IPS 5 was higher to experimental class 1. However, the IPS 4 in experimental class 1 was more significant to experimental class 2. While for the IPS 6 in both classes showed the same percentage value.

Furthermore, the final PSA based on the post-test results indicate that both classes experienced an increase from the initial PSA. Current PSA conditions in experimental classes 1 and 2 were the same as the IPS 1. However, the IPS 2 and IPS 3 of the experimental class 2 were higher than the experimental class 1. Conversely, on the other three indicators, IPS 4, IPS 5, and IPS 6 in the experimental class 1 were higher than experimental class 2. This fact shows that students' PSA who implemented the causal thinking process with scaffolding type 2b were higher in the IPS 4 to IPS 6. Therefore, it represents that although overall there is no difference in effect between the causal thinking process with scaffolding type 2a and 2b; type 2b has a more positive effect on these three indicators than type 2a. The examples of typical questions and answers were used for students in experiment 1 and experimental class 2 to add to the depth of this discussion. Both of these experimental classes were tested with the same problem to show whether the six PSA indicators appeared in the two groups.

Examples of questions: P object is standing in front of a concave mirror. The position of the object can be at the center of the mirror curvature or between the vertex and the center of the mirror curvature. Based on this fact, note the following statements related to the P shadow: (1) real, inverse, equal to P, (2) real, upside down, smaller than P, (3) virtual, upright, bigger than P, (4) real, upside down, and bigger than P. Of the four statements, which one is likely to occur? Explain how it happened, state the concepts, principles, laws, and physics theories that are related!

How to solve the problem: Students are asked to write down which statement number of the four statements has the chance to occur. In the instructions should be notified to students that of all statements given there is a possibility that all statements may not occur, some statements may occur, or all statements may occur. Furthermore, outside of the statement provided, students are also given the opportunity to add answers or other statements that might occur.

Answer: Possible statements are statements (1), (3), and (4).
Explanation:
Statement-1: occurs when object P is right at the center of the mirror curvature
Statement 3: occurs when object P is between the vertex and the mirror's focal point
Statement-4: occurs when object P is between the center of the curvature and the focal point of the mirror
Additional answers: no shadows or shadows are formed at infinity.
Statement (additional answer): occurs when object P is right at the mirror's focal point.

The results of this study indicate that the Modified causal thinking process with scaffolding

type 2a with a 5% significance and also the type 2b can increase students' problem-solving ability (PSA). However, the improvements in PSA in both treatments were not significantly different. The results of this study are in line with previous studies conducted by Rohkmat (2013) that causal and analytical thinking processes (CTAP) with a significance level at 5% have a positive effect on increasing PSA. However, the type or pattern of the causal thinking process used is a standard pattern. Regarding the causal thinking process with scaffolding type 2a, Putrie (2016) and Tamami, Rokhmat, and Gunada (2017) have conducted similar research. The research results of Putrie (2016) show that the modified causal thinking process with scaffolding type 2a assisted by worksheet on dynamic electrical learning with a significance of 5% can increase students' PSA. Similar results also occur for the study of geometric optics (Tamami et al, 2017). Regarding the causal thinking process with scaffolding type 2b, Yuliana (2016) and Yuliana, Rokhmat, and Gunada (2017) stated that learning by applying causal thinking processes with scaffolding type 2b assisted by worksheet has a positive influence on students' PSA. Other research results by Helmi, Rokhmat, and Ardhuha (2017) stated that the modified causal thinking approach with scaffolding type 2b assisted by the worksheet has a positive effect on students' PSA on the dynamic fluid material.

Although each type affects increasing PSA, the assistance in the form of explanation added to the worksheet of CTP scaffolding type 2b does not have a significant effect on increasing students' PSA. It is because of some students in class 1 did not answer the reasoning since they were confused even though they had been given explanatory assistance, especially in determining the concepts, principles, theories, and related physical laws. It is related to the constraints faced in the research process, and it is proved as the limitation of the study.

The obstacle was the limited time to discuss physical phenomena; then each group was only provided by one worksheet. Therefore, the learning process was limited, only some students in each group could understand the problem. Next, students' ability to comprehend the worksheet was limited. The worksheet was unfamiliar to them, and it made them asked many questions related to the command in filling the worksheet space. Also, they were still confused in understanding the sentences in the physical phenomena presented in the worksheet.

To overcome these limitations, students need to do an initial task to recall their basic knowledge in solving physical phenomena and do not take long to find references. Also, it is better to provide the worksheet for students with at least two students one worksheet to facilitate the learning process. Furthermore, an explanation in using the worksheet must be conducted at the beginning of the lesson. The sentences modification to fit the students understanding is suggested to ease the learning process. Also, special handouts related to the material being discussed can be considered; therefore, the exploration process of reference material can be more effective. These recommendations are in line with Rokhmat, Marzuki, Hikmawati, and Verawati (2017), which means that to overcome the limitations of implementing the causal thinking approach, among others, by providing handouts, using only one phenomenon in each worksheet, is given an example of a phenomenon that has been answered in full, as well as the provision of preliminary assignments at least two days before face-to-face learning.

CONCLUSION

Based on the results of research conducted in MAN 2 Mataram in class XI students in the 2016/2017 school year, data analysis with a significant level of 5%, and discussion, it can be concluded that the modified causal thinking process with scaffolding type 2a influenced the improvement of the problem-solving ability (PSA) of students. However, there was no significant difference between the two CTPs. Assistance in the form of explanation on the causal thinking process with scaffolding type 2b was only seen in some indicators of problem-solving (IPS), and it did not significantly affect the increase in PSA.

REFERENCES

Amer, A. (2005). *Analytical Thinking*. Cairo: Center for Advancement of Postgraduate Studies and research in Engineering Sciences Faculty of Engineering Cairo University (CAPSCU)

Badan Standar Nasional Pendidikan (BSNP). (2006). *Standar Isi untuk Satuan Pendidikan Dasar dan Menengah*. Jakarta: Badan Standar Nasional Pendidikan (BSNP).

Barba, Robertta, H. (1998). *Science in the Multicultural Classroom: a guide to teaching and learning*. Unitet States of America: Allyn &

Bacon.

Fisher, A. (2009). *Berpikir Kritis*. Jakarta: Erlangga.

Helmi, F, Rokhmat, J, & 'Ardhuha, J. (2017). Pengaruh Pendekatan Berpikir Kausalitik Berscaffolding Tipe 2b Termodifikasi Berbantuan LKS terhadap Kemampuan Pemecahan Masalah Fluida Dinamis Siswa. *Jurnal Pendidikan Fisika dan Teknologi*, 3 (1), 68-75.

Marini MR. (2014). Analisis Kemampuan Berpikir Analitis Siswa dengan Gaya Belajar Tipe Investigatif dalam Pemecahan Masalah Matematika. Jambi: FKIP Universitas Jambi. Diakses online di http://e-campus.fkip.unja.ac.id/eskripsi/data/pdf/jurnal../RRA1C209069.pdf pada15 September 2015.

Putrie, S.D. (2016). *Pengaruh Proses Berpikir Kausalitik Berbantuan LKS Ber-scaffolding Tipe 2a Modifikasi terhadap Kemampuan Pemecahan Masalah Fisika Siswa Kelas X SMA Negeri 3 Mataram Tahun Pelajaran 2015/2016*. Skripsi Sarjana S1 Pendidikan Fisika tidak diterbitkan. FKIP UNRAM, Mataram.

Rokhmat, J., Agus S., & Dadi R. (2012). Pembelajaran Fisika Berbasis Proses Berpikir Kausalitas dan Berpikir Analitik (PBK-BA), Suatu Pembiasaan Berpikir Secara Terbuka. *Prosiding Seminar Nasional IX Pendidikan Biologi*. Semarang: FKIP UNS.

Rokhmat, J. (2013). *Peningkatan Kemampuan Pemecahan Masalah Mahasiswa Calon Guru Fisika Melalui Berpikir Kausalitas dan Analitik*. Disertasi Program Doktor tidak diterbitkan. Program Doktor Pendidikan IPA Universitas Pendidikan Indonesia (UPI), Bandung.

Rokhmat, J., Marzuki, Hikmawati, & Verawati, N., N., S., P. (2017). Instrument Development of Causal Thinking Approach in Physics Learning to Increase Problem Solving Ability of Pre-service Teachers. *American Institute of Physics (AIP) Conference Proceeding, p: 03000-1 – 030001-9.*

_____, (2017b). The Causal Model in Physics Learning with a Causal-thinking Approach to Increase the Problem-solving Ability of Pre-service Teachers. Universiti Putra Malaysia: *Journal of Social Science and Humanities (JSSH),* 25(S), 153-168.

Setyosari, P. (2012). *Metode Penelitian Pendidikan dan Pengembangan*. Jakarta: Kencana.

Susanto, E.P. (2011). *Pengaruh Metode Diskusi Bentuk Workshop terhadap Hasil Belajar Fisika Siswa Kelas VIII dengan Meninjau Aktifitas Siswa di SMP N 19 Mataram Tahun Ajaran 2010/2011*. Skripsi Sarjana S1 Pendidikan Fisika tidak diterbitkan. FKIP UNRAM, Mataram.

Tamami, F, Rokhmat, J, & Gunada, I.W. (2017). Pengaruh Pendekatan Berpikir Kausalitik Scaffolding Tipe 2a Modifikasi Berbantuan LKS terhadap Kemampuan Pemecahan Masalah Optik Geometri dan Kreativitas Siswa Kelas XI SMA N 1 Mataram. *Jurnal Pendidikan Fisika dan Teknologi*, 3 (1), 76-83.

Yuliana, I. (2016). *Pengaruh Proses Berpikir Kausalitik (PBK) Berbantuan LKS Ber-scaffolding Tipe 2b Modifikasi terhadap Kemampuan Pemecahan Masalah Fisika Siswa Kelas X SMA Negeri 2 Praya Tahun Ajaran 2015/2016*. Skripsi Sarjana S1 Pendidikan Fisika tidak diterbitkan. FKIP UNRAM, Mataram.

Yuliana, I., Rokhmat, J., dan Gunada, I., W. (2017). Pengaruh Berpikir Kausalitik Ber-Scaffolding Terhadap Kemampuan Pemecahan-Masalah Kalor pada Siswa SMA. UNS: *Prosiding seminar nasional fisika & aplikasinya (SNFA).*

DESIGN OF EXPERIMENTAL PROBLEM SOLVING-BASED LEARNING PROGRAM TO IMPROVE MENTAL MODEL AND TO ENHANCE MENTAL-MODELING ABILITY

Supriyatman[1]*, A. Suhandi[2], D. Rusdiana[2], A. Samsudin[2], F. C. Wibowo[3], J. Mansyur[1]

[1]Physics Education Study Program, Teaching and Education Faculty
Universitas Tadulako, Indonesia
[2]Department of Physics Education, Faculty of Mathematics and Natural Sciences
Universitas Pendidikan Indonesia, Indonesia
[3]Department of Physics Education, Faculty of Mathematics and Natural Sciences
Universitas Sultan Ageng Tirtayasa, Indonesia

ABSTRACT

Research on developing experimental problem solving-based learning program to overcome the low mental model (MM) and mental-modeling abilities (MMA) physics teacher candidate in one of the college teachers in Palu have been conducted. Mental model construction is the "core" of meaningful learning and along with MMA (modeling) become a keyword to understand the key concepts in the science learning. The development of this learning program was using R & D method. Development process from requirement analysis phase until implementation process has already been described using 4D model: define, design, develop and disseminate. The subject matter of this research was the Basic Physics II course on the topic of electricity and magnetism. Based on the data analysis and findings at each stage of development, it is concluded that the learning program stages which have improved MM and also enhanced the MMA of physics teacher candidates consist of learning orientation phase; orientation to the problem; pre-experimental brainstorming; experiment; evaluation; as well as the phase of reinforcement and follow-up.

ABSTRAK

Penelitian tentang pengembangan program berbasis eksperimen problem solving untuk mengatasi rendahnya mental model (MM) dan mental-modeling abilities (MMA) calon guru fisika di salah satu guru perguruan tinggi di Palu telah dilakukan. Konstruksi model mental adalah inti dari pembelajaran yang bermakna dan bersama dengan MMA (pemodelan) menjadi kata kunci untuk memahami konsep-konsep kunci dalam sains. Pengembangan program pembelajaran ini menggunakan metode R & D. Proses pengembangan dari tahap analisis kebutuhan hingga proses implementasi dijelaskan menggunakan model 4D: define, design, develop, disseminate. Materi yang dikaji dalam penelitian ini adalah mata kuliah fisika dasar 2 tentang topik listrik dan magnet. Berdasarkan analisis data dan temuan pada setiap tahap perkembangan, disimpulkan bahwa tahapan program pembelajaran yang telah memperbaiki MM dan juga meningkatkan MMA calon guru fisika terdiri dari fase orientasi pembelajaran; orientasi pada masalah; pra-brainstorming eksperimental; percobaan; evaluasi; serta fase penguatan dan tindak lanjut.

Keywords: Course Program; Mental Model; Mental-Modeling Ability (MMA); Problem Solving Laboratory

INTRODUCTION

Mental models and mental modeling abilities are two important factors in the problem solving process (Mansyur, 2010; Wang, 2007;

and Tallman and Henderson, 1999). Mansyur (2010), reported that the higher the academic level of a person, the better the mental model and the higher the ability to solve problems. This means that a person's mental model is dynamic can change with increasing learning experience (Corpuz & Rebello, 2011) and context dependent (Didiș, N., et al, 2014). A good

*Correspondence Address:
Jl. Soekarno-Hatta KM.9, Tondo, Mantikulore,
Kota Palu, Sulawesi Tengah 94148
E-mail: spymfis.untad@gmail.com

mental model has been constructed from links between elements of the problem description and underlying knowledge (Mansyur, 2010).

The process of understanding how the system works requires individuals to construct a mental model of the system in their minds. This can be done by building a network of related concepts and understanding the functional relationship of a number of different aspects and levels of the system based on daily knowledge and experience (Vosniadou, et al, 2004). Jansoon, et al, (2009) divides mental model levels into three levels:

Level 1: the model is seen as a "toy" or a "copy" of reality. The model created at this level is not based on concept and only based on experience that cannot explain the problem.

Level 2: the model can lead to goals explicitly and specifically. The model made at this level is based on the concepts and phenomena that are displayed (context) in the problem but cannot be developed.

Level 3: the model has been constructed to develop and test an idea, and can be manipulated and operated against the test. Models at this level are dynamic, can be constructed based on concepts, contexts, and can be developed to solve problems that are seen in the presence of several alternative solutions.

The ability to use or to change mental models while the model used cannot be applied or is inappropriate in the problem solving process is called mental-modeling ability (MMA). According to Wang (2007), high mental-modeling ability (H-MMA) is characterized by the emergence of abilities:

1) Resulting mental models in the form of diagrams or other relevant forms of representation.
2) Being able to reconstruct, manipulate, or adjust the mental model based on propositions or problem conditions.
3) Re-arranging the approach based on the problem.
4) Monitoring the process of explaining and constructing the mental model, as well as
5) Checking and matching mental models and answering problems using an alternative approach if the problem is relatively new.

It is undeniable that the ultimate goal of learning physics is the ability to solve problems (Korsunsky, 2004). Likewise on the standard of higher education learning processes that require problem solving competencies for graduates (Kemenristekdikti, 2015). The transition of the problem solver categories of novice to an expert requires an increase in problem solving abilities (Walsh, et al, 2007). This increase is able to be trained through problem-based learning (Komariah, K., 2011; Tallman & Henderson, 1999). The results of the research by Supriyatman, et al (2014) on physics education students of one of the state universities in the Central Sulawesi in the second and fourth semester who were attending the Basic Physics II and Magnetic-Electricity courses, showed that the low level of students' mental models in the concepts of electricity and magnetism, and even tended to misleading in choosing a concept and experiencing misconceptions.

Based on the results of preliminary studies that have been conducted, it was found that the learning activities do not support the improvement of mental model abilities of students. This fact is quite apprehensive considering they are prospective teachers who will teach these concepts to their students. Therefore, to improve the ability of students' mental models, especially in electricity and magnetic topics, it is necessary to design learning programs that can train students to solve problems regarding with the topics systematically. One of the methods utilized is hands on and minds on activities. By using hands on and mind on activities, students are able to be trained to solve problems, increase their learning experience and are able to use less energy in accessing and organizing cognitive elements.

METHOD

This research is a research and development research (R & D) of 4D model (define, design, develop and disseminate) from Thiagarajan, et al (1974) to develop Basic Physics II courses on electricity and magnetism concepts that is able to improve mental models and to enhance the MMA of physics teacher candidates. The preliminary step of this research were initial investigating to the students' mental model and MMA profile on electricity and magnetic concepts (Supriyatman, et al., 2014); to analyze the curriculum documents, lesson plan (SAP), and final test documents. At the design stage, based on the results of the mental model analysis, MMA, and the document profiles, the purpose of each step of the development and constructing of the learning program have already been planned.

The learning program carried out was complemented by several instruments, including SAP (lesson plans), LKM (students' work-

sheets), PD (lecturers' guidelines) and problem solving tests related to the topics which were studied. The four learning instruments were validated by four physics experts both in terms of content and learning aspects. The results of expert validation are then utilized as the basis for the revision and the revised instruments are then tested. Problem solving in addition to expert validation was also carried out field validation.

To obtain field validation, the draft of the problem solving test was tried out to 49 second semester students who had attended electricity and magnetism lectures. Furthermore, based on the results of the validity analysis, a number of questions were chosen which were ready to be utilized in the study. The next step, SAP, LKM, PD, and problem solving tests are implemented in Electricity and Magnetism learning which is attended by 33 students in the fourth semester. The research data at this phase have already been analyzed and utilized as a consideration to revise the draft program and the instrument (develop-phase). The results of the revision of this phase are then re-validated. Furthermore, to determine the effectiveness of learning programs that have been designed, revised research instruments are then implemented to the 29 students participating in the Basic Physics II lecture on the concept of electricity and magnetism (disseminate phase).

Learning indicators of successful program implementation are determined from a minimum of 75% of respondents (lecturers and students) who agree and strongly agree and the improvement of mental models, MMA and problem solving scores. The instruments utilized to collect data were students' response sheets, lecturers' response sheets, Electricity problem solving tests, and Magnetism problem solving tests. In problem solving tests, the methods of data collection utilized were three ways, namely traditional tests (paper and pencil test), thinking aloud, and semi-structured interviews to explore the consistency of student answers, especially in determining mental models and MMA.

RESULTS AND DISCUSSION

Define phase

Document analysis results in the define phase show that SAP and experiment instructions are still traditional learning, the learning carried out still uses the pattern: Lecture - Exercise - Assignment. Experimental guidance are still in the form of cook-books and separate from supporting courses. Exam questions for students are also rarely found using a form of problem solving tests.

Design phase

The learning program has ever been developed consists of learning tools: lecture models as learning process syntax contained in the learning implementation of lesson plan (SAP), student learning guides contained in student worksheets (LKM), lecturer guidelines (PD) as lecturer guidelines in guiding student learning and problem solving tests as an instrument to conduct an assessment in exploring mental models, mental-modeling ability (MMA) and problem solving abilities.

The learning model developed is a problem solving based lecture model based on the Simanjuntak's framework (2012) which is used to improve meta-cognition skills. The application of this model is able to improve student cognition and meta-cognition on the topic of Kinematics and Dynamics in the medium category (Mariati, et al, 2017). This model consists of five phases: Phase 1 Orientating students on problems; Phase 2 Organizing students to study; Phase 3 Guiding a problem-solving based investigation individually and in groups, Phase 4 Developing and presenting the results of the investigation, Phase 5 Strengthening and following-up to learning. The part developed in this research is to include the process elements in the formation of mental models in Phase 3 by adding a POE strategy (predict, observe and explain). This strategy has been utilized by Wang (2007) and Khanthavy (2012) to investigate students' mental models. These phases and the activities of lecturers and students in each phase are stated in SAP.

Experiments conducted in this study using real lab and virtual lab. Real lab is used in experiments that require real observation (can be observed by the five human senses), whereas in experiments that require observation of abstract quantities, a virtual lab have been used. According to Zacharia and Anderson (2003), understanding the concept of students on the abstract concept by experiment using a virtual lab is higher than that of students who use real labs. This program is designed in nine-meetings with three lecture units (three credits), with a composition of seven lectures and two exams.

The students' activity sheet (LKM) developed has been adapted from the models of

Heller, Keith, and Anderson (1992) which featured nine steps of problem solving strategies in solving physics problems experimentally: (1) questions (real-world problems); (2) equipment; (3) prediction; (4) method questions; (5) exploration; (6) measurement; (7) analysis; (8) evaluation and (9) conclusions. Topics displayed in this problem solving consist of seven topics, that are; electric charge, capacitors combination, switch and lamp combination, RC circuit, voltmeter, induction emf, and generator.

Lecturer's guidelines (PD) have been developed referring to the LKM that have been made. PD as a lecturer guide was used to conduct problem-based experiment processes so that the structure follows the structure of the LKM. Basically this PD contains the possibility or alternative answers of students in doing problem solving.

Assessment instruments have been developed referring to the real-world problem of Heller & Heller (1999) in their book of Cooperative Group Problem Solving in Physics. Problem solving tests in the form of rich problem tests, students as problem solvers are required to solve contextual problems using several related concepts. Students should have being the ability to analyze problems, link concepts between contexts, make analogies, and explain using appropriate representations (Gilbert, et al, 2008).

Problem-solving tests (PS) have electricity and magnetism topics that are used differently from essay tests in general, especially in the test instructions. The test instructions are listed: "Do the following questions by giving answers based on your knowledge. Write clearly along with a sketch or picture as an illustration of everything you think about when answering the question on the answer sheet. This guide is written with the intention that researchers can access their mental model as a substitute for thinking aloud.

Develop phase

Model and instrument tests have been conducted on 4th semester students who participated in Electricity and Magnetism courses. The model used consists of 5 phases: Phase 1 Orientating students on the problem, Phase 2 Organizing students for learning, Phase 3 Guiding individual and problem-solving based group inquiry, Phase 4 Developing and presenting the results of investigations, Phase 5 Strengthening and following-up learning. This model has been elaborated in the program

tools in the form of SAP and PD as instructors for lecturers and LKM as a guide for students in solving experimental-based problems. Lecture material at the Basic Physics level consisting of four topics on electricity problems and three topics on Magnetism problems planned in seven meetings and two tests. The electricity problem-solving test is carried out after the end of the electricity topic and the Magnetism problem-solving test is carried out after the end of Magnetism topic. Each meeting uses 3x50 minutes which is equivalent to three credits.

This testing phase has aver used one group post-test designed and obtained data about mental models, MMA and problem solving scores as shown in Table 1. Increased problem solving scores (PS) from 16% who had a score above 7 in electricity material to 41% in magnetic material. This can also be seen from the increase in the number of students who experienced MM improvement at level 3 from 6% to 14%, and MMA on H-MMA from 8% to 19%.

Table 1. Recapitulation of program test results

Aspects measured Electricity		Topics/ Number of Students (%)	
		Magnetism	
Level of MM	NC (%)	10	15
	Level 1 (%)	59	43
	Level 2 (%)	25	29
	Level 3 (%)	6	14
Categories of MMA	Blank (%)	10	15
	L-MMA (%)	61	29
	M-MMA (%)	21	38
	H-MMA (%)	8	19
Scores of PS ≥ 75		16	41

Notes:
NC : not clear (mental model not accessible / answer blank)
Blank : MMA cannot be accessed
% Δ : Percentage of the number of students who experienced a better change
L-MMA : Low-mental modeling ability
M-MMA : Moderate-mental modeling ability
H-MMA : High- mental modeling ability

In the testing phase although it has described an increase in PS scores, an increase in the number of students who managed to improve MM, and an increase in MMA, but there are still deficiencies in the learning process. These weaknesses include students still hav-

ing difficulty finding concepts related to problems; and connecting with the problems given to the right solution; and do not conduct evaluation and meta-cognition (Supriyatman, et al, 2018). These findings were then used as material in revising lecture programs based on developed problem solving experiments.

The implementation phase was carried out using the pretest - post-test design method to 29 students participating in the Basic Physics II course. The learning phases carried out are as follows: Phase 1 Orienting students to the learning; Phase 2 Orienting students to problems; Phase 3 Guiding students to pre-experimental brainstorming; Phase 4 Guiding individual- and group- inquiry based on problem solving; Phase 5 Evaluating problem solving results, and Phase 6 Strengthening and following-up learning. These stages are then refined by sharpening the emphasis on MM construction (Phase 3) and the characteristics of H-MMA (Phase 5). The improvement of this stage was able to reaffirm the increase in PS scores, MM improvement, and increase in the teacher's MMA as shown in Table 2.

Table 2 shows that students who have participated in learning programs and problem solving-based experiment experience an increase in problem-solving skills both on the to-

pic of electricity and on the topic of magnetism. This increase is indicated by an increase in PS scores of 38.3% in the topic of electricity and 38.1% in the topic of magnetism. The lecture is able to improve MM students both on electricity topics and on magnetism topics. Students experience MM improvement in the topic of electricity at 58% and 59% on magnetism topics.

The lecture program that was developed has also increased student MMA both on both topics. The increase in student MMA was obtained from the percentage of students who experienced an increase in the MMA category in the post-test results. Students experienced an increase in MMA on the topic of electricity by 63% and on the topic of magnetism by 64%.

The following is an example of improving the level of M25 students' mental models in working on electricity material problem solving tests: Problem: "As a researcher, you are tasked with investigating the electricity properties of metal modifications of your research. Your initial step will be to determine the metal resistivity properties (ρ) and for this purpose you prepare two similar metal groups. The first group consists of three metal rods of the same diameter but vary in length and the second group consists of three metal rods with different diameters but the same length. Make predictions from the two

Table 2. Recapitulation of the results of program implementation.

Aspects Measured	Pretest	Electricity Topics		Magnetism Topics	
		Posttest	Pretest	Posttest	
Level of MM	NC	13	2	16	7
	Level 1	55	29	51	22
	Level 2	30	52	30	39
	Level 3	2	17	3	32
	%Δ	58		59	
Categories of MMA	Blank	13	2	15	7
	L-MMA	66	35	60	24
	M-MMA	21	44	22	37
	H-MMA	0	19	3	15
	% Δ	63		64	
Problem- solving Scores	Scores	3.5	5.9	3.3	6.9
	N-Gain	38.3		38.1	

Notes:
NC   : not clear (mental model not accessible / answer blank)
Blank   : MMA cannot be accessed
% Δ   : Percentage of the number of students who experienced a better change
L-MMA : Low-mental modeling ability
M-MMA : Moderate-mental modeling ability
H-MMA : High- mental modeling ability

groups of metals, design the steps of the investigation, what data are needed, make a table of observations, and analyze the data."

Answers to the initial M25 student tests in the level 2 mental model category:

"To investigate the electricity properties of metal modification, the data needed to determine the metal resistivity level (ρ) is the length, cross-sectional area, current. Based on this we need to see the current flowing to see the magnitude of metal resistivity. Thus, the metal resistivity which is influenced by the cross-sectional area and the length of the metal rod and the current flowing in the metal rod we can determine the resistivity level."

The answer to M25 above has shown that the model formed in analyzing problems has used the correct concept. The M23 model has explicitly guided the expected solution. But at the end of the answer, M25 students do not display the form of representation in the form of equations or images that explain or guide in the problem solving process. So that M25 is categorized as MM level 2.

M25 student final test answers:

"After reading the problem first in this case that is to determine the metal resistivity properties (ρ) and two similar metal groups are prepared with the first group division of three metal rods of the same diameter but varying in length and the second group consists of three metal rods whose diameter different but the same length. The thing that needs to be done to test is to prepare an electricity measuring device such as a voltmeter and ampere-meter and then we utilized the power supply, the ruler to measure the length and micrometer of the screw and the calipers as other supports. Then we obtained the data needed, namely, the length of the metal rod, diameter, current strength, and stress on the metal rod. In determining metal resistivity (ρ), this process has been influenced by two factors, namely the length and width of the conductor or metal. The diameter we obtain is used to calculate the metal cross-sectional area with us assuming a metal cross section is a circle so that $A = \pi r^2$."

Table 3. (for the same diameter and length)

Length (M)	D(m)	A (m^2)
5.10^{-1}	2.10^{-2}	
4.10^{-1}	2.10^{-2}	
3.10^{-1}	2.10^{-2}	

Table 4. (for different diameter and the same length)

Length (M)	D(m)	A (m^2)
2.10^{-1}	5.10^{-2}	
2.10^{-1}	4.10^{-2}	
2.10^{-1}	3.10^{-2}	

It can be seen that for similar materials have "the same metal resistivity".

The answer to M25 appears to be an improvement in the use of representations in the form of tables and equations used in the problem solving process. The dynamics of the model built by M25 guide him in solving problems. So that M25 in the final test is categorized as MM level 3.

Example of Improvement of MM M23 students on magnetism context number 2. Answer of M23 at MM level 2 at initial test and level 3 at final test:
M23 initial test answer:
"I decided that because, as we know, the compass needle always points towards the north and south which is caused by being attracted by the South Pole and the north pole of the earth's magnet, which is why I decided to use a compass. Then to determine the magnitude of the magnetic field qualitatively using a compass in my opinion, by using an electric current wire the coil of iron-core wire that is electrified can draw iron and steel. This shows that an electric wire coil can produce a magnetic field. When the electric current flowing in the conveyor is enlarged, it turns out that the compass needle pole deviates even further."
M23 final test answers:
"In this case I decided to use a compass because the first there was no tool to be used. Then the second, as we know, the earth's magnetic poles move so slowly that the compass can still function if it is used to measure magnetic fields. Then to determine the magnitude of the magnetic field qualitatively, namely: a compass needle placed in a magnetic field will align its position with the magnetic field line. The North Pole will show the direction of the magnetic field at that point. If the com-

pass needle is moved at the point around the wire that is running, then the compass needle will appear to move in the direction of the tangent to the circle centered on the wire. From the above events it can be concluded that the direction of the magnetic field line due to the current wire is parallel to the tangent lines of the circle centered on the wire with the direction indicated by the compass north pole. There is another way besides using the compass in this case by using the right hand rule."

The final test pattern answer M23 indicate that the thinking pattern constructed by M23 showed an understanding that the field presented by the compass is a magnetic field at the point where the compass is located, using the correct concept with a fairly clear expansion. M23 also builds its mindset by showing alternative solutions that can be developed. M23 is not rigid with the models that have been built at the beginning of problem solving.

Level 3 mental model (MM) category is also shown by M15 and M22 in the context of number 3 magnetic material with the final test answers as quoted below.

M15 final test answers:

"First, speed up the flow of water until it rotates faster we can add the rotor in the generator section, because this rotor is a rotating part of the generator. This rotor consists of a magnetic field that produces magnetic flux. Second, increase the number of coils. It is because when the spinning coil causes a change in magnetic flux so as to produce a current, the current enters the circuit with the outer circuit, so that the lamp turns on, because of a coil that can rotate through a magnetic field and produce magnetic flux. The rotating coil causes a change in magnetic flux so that it cuts the coil. This will produce a current. Like the Figure 1.

This respondent's answer has used the concept clearly, linking the problem with the generator working principle until the reasons for the problem are found. The mental model of respondents has guided specific and explicit goals. Respondents in explaining physics phenomena also use representations in the form of images, diagrams and analogies.

M22 final test answers:

"The reason why two alternative solutions to the problem were taken because accelerating the flow of water will cause the turbine will spin faster. The faster water flow and turbines spinning rapidly the better the electric generator work (based on principle), so that the light produced will be maximally bright and

there will be no more dim lights. Because basically the lights that light up with the help of an electric generator will also die or get to the minimum point (0) but we cannot see it because it is visible because the resulting frequency is approximately 60 Hz. It means 60 per second waves. To produce a bright enough light by increasing the number of coils on the electric generator it is very supportive because the more the number of coils will produce a large magnetic induction so that the current will also increase."
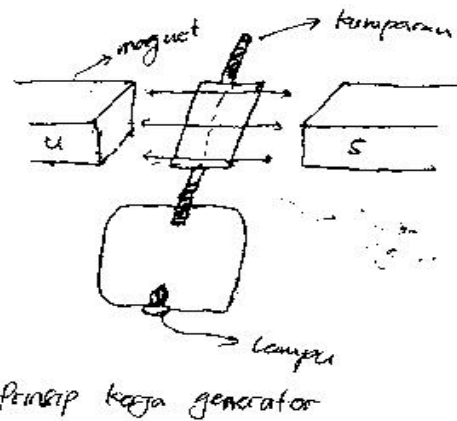

Figure 1. Working principle of generator (M15 student answer)

Respondents at this level are able to build a mental model by connecting the problem of lights that flash with the speed of water flow and turbines. Respondents are also able to connect the concept of waves to alternating current (AC) with the lights through the frequency concept; able to represent mental models macroscopically and microscopically; and using mathematical representations to further clarify the physical phenomena displayed.

The description above shows that the mental models of prospective physics teacher students on the concepts of electricity and magnetism are diverse. Each individual has their own way of building their mental model based on experience, analytic skills, and also the establishment of concepts they have. Students build their mental models depending on context, are dynamic and depend on student groups (the initial knowledge they have). The data are in line with research conducted by Corpuz and Rebello (2011) which revealed that mental models are essentially dynamic and context dependent and depend on the expert and novice groups (Chi, et al, 1981). This research data shows that students who have a

level 1 mental model do not have an establis-hed concept and are not able to connect bet-ween reality and their concepts. This is the im-portance of the stage of brainstorming (Phase 3) carried out together in groups consisting of heterogeneous in terms of academic ability. At this stage also carried out efforts to train pros-pective physics teacher students in building, changing, or modifying mental models and using them in problem solving (mental mode-ling ability process).

Activities in this learning program directly make students care about doing meta-cogni-tion, what and how mental models can help in understanding problems (Mark, 2012). The same thing is also stated by Lee, et al (2005) that alternative conceptions and mental models as part of cognitive psychology if combined in science learning, will be the approach that produces the best learning (Lee, et al, 2005). Likewise the tests used in evaluating utilized a form of rich problem tests. This form test al-lows students to use all their knowledge skills to analyze qualitatively before manipulating mathematical equations, connecting concepts in context, looking for alternatives, and evalua-ting the solutions (Al-Diban, & Ifenthaler, 2011; Heller & Heller, 2010).

The program have already trained stu-dents to produce mental models in the form of diagrams or other relevant forms of representa-tion (Phase 3), reconstructing, manipulating, or adjusting mental models based on propositions or problem conditions (Phase 4). This learning program also trains students to reconstruct their approaches to problems and constant-ly monitors the process of explaining and constructing their mental models, checking and matching their mental models and answering using alternative approaches if problems are relatively new (Phase 5). From this whole pro-cess, it is expected that trained students solve problems based on H-MMA indicators/ criteria. This problem solving based learning strategy is consistent with the results of Wang (2007) research that applies problem-based lectures that have been able to increase student MMA on the molecular structure and Marks (2012) who applies problem-based learning and POE strategy interviews to improve students' mental modeling skills on dynamic electricity topics.

The increase in student MMA is both in the topic of electricity and magnetism, in line with research conducted by Wang (2007) which resulted that students with novice and intermediate categories are more easily inter-vened through learning than the expert group. Jusman (2010) in his research found that MMA respondents increased along with the increase of their academic level. This implicitly explains that the learning process influences the inc-rease in the MMA category (Mansyur, 2010; Maloney, et al, 2008; Koponen, 2007).

The following are examples of thinking aloud and Interview about Event (IAE) of M22 respondents. Transcripts of thinking aloud M22:

"[Reading the problem of number 1 elec-tricity] ... um ... the location of the farm loca-tion ... under SUTET (high voltage power line) [the student repeats but slowly while analyz-ing the problem]. Eee .. [scratching his head while looking blankly in the future like thinking about something]. [Returns writing] compass ... draws a compass [silence] (the results of the image are shown in Figure 2). (Again watch-ing the problem) using a compass ... using a compass. eeee ... we have what this is ahhhhh ... We know that the compass ... (while looking around) is a tool ... (staring up) that can help find out the amount of current. Because of the increasing voltage, the ... (pause) the compass will be affected by the voltage because the compass is also affected by the voltage. So ... (while looking at the question closer) the elec-tricity ... then ... the bigger the magnetic field ... the compass will deviate, deviate ... (write) "this compass before it is in the location of the SUTET. After the location of the SUTET, the compass will deviate either up or down.
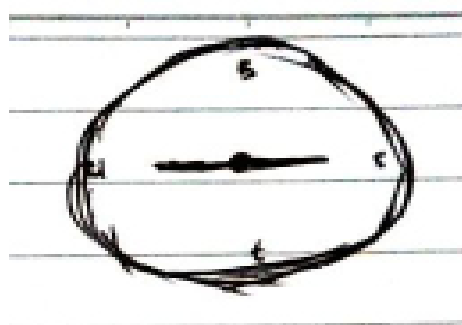
Figure 2. Figure of compass by M22

M22 writes (draws) the compass after being in the SUTET location (drawing) Figure 3.

"Suppose this south east is west of this north. Here is a deviation."
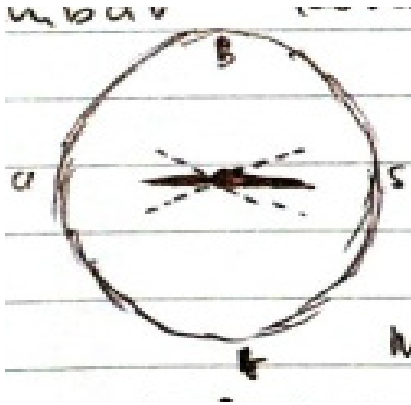
Figure 3. Picture of compass deviation by M22

"The images of these points are images of deviation from the compass needle (Figure 3). Deviations up or down we do not know depends on the source of the magnet."

The results of the interview with M22 also confirmed that M22 remained in its concrete thinking, namely compass. M22 does not think of the concept that "around a wire with a magnetic field". The following is the quote:

Q: After you read the problem at number one what do you think?

M22: It's good, sir, because it's affected by magnetic fields. Because the greater the magnetic field, the compass gets bigger and bigger [...].

Q: What do you think is a solution?

M22: I think that is a solution from me too sir...

Q: Or ... has there been any previous experience?

M22: If you don't have experience.

Q: [...] do you also think about what concepts can be applied to solve the solution?

M22: I do not master the concept of sir. Still shallow....

M22: Yes Sir. Make what I think is a compass. So, I described the compass first.

Thinking aloud results and M22 interviews in the context of number one magnetic material in forming a problem solving model that starts with analyzing the problem context qualitatively along with images, always monitoring the problem solving process by matching each answer with the problem, and self-checking the results of the work. But the model built at the beginning does not change when there is a new thought "the magnetic field is affected by the magnitude of the voltage" (perhaps considered wrong), M22 remains in the compass as a concrete matter.

CONCLUSION

Based on the data analysis and the discussion, it can be concluded that the learning program developed is able to improve MM and to increase the MMA of Physics teacher candidates, especially the concepts of electricity and magnetism. A significant phase in improving MM is the phase of brainstorming (Phase 3). At this phase students are guided to form MM through discussions with group members. A significant phase in improving MMA is the phase of guiding individual and group investigations based on problem solving (Phase 4) and the phase of evaluating problem solving results (Phase 5). In these two phases students are trained to use MM to solve problems and monitor every stage of the problem solving process.

ACKNOWLEDGMENT

REFERENCES

Chi, M.T.H., Feltovich, P.J., & Glaser, R. (1981). Categorization and Representation of Physics Problems by Experts and Novices. *Journal of Coginitive Science.* Vol.5**,** (2), 121-152.

Corpuz, E. D., & Rebello, N. S. (2011). Investigating students' mental models and knowledge construction of microscopic friction. II. implications for curriculum design and development. *Physics Review Special Topics PER.* **7**, (2), 020103-1 – 020103-8.

Didiş, N., Eryilmaz, A., & Erkoç, Ş., (2014). Investigation students' mental models about the quantization of light, energy, and angular momentum. *Physical review special topics-Physics education research. Vol. 10, 020127 (2014), p.020127-1 – 020127-28.*

Gilbert, J.K., Reiner, M., & Nakhleh, M. (2008). Models and Modeling in Science Education, visualization: theory and practice in science education. Vol 3. UK: Springer.

Heller, P., Keith, R., & Anderson, S. (1992). Teaching problem solving through cooperative grouping. Part 1: Group versus individual problem solving. *American Journal Physics (Am.J.Phys).* **60,** (7), 627-636.

Heller, K., & Heller, P. (1999). *Problem-Solving Labs. Introductory Physics I sMechanics. Cooperative Group problem-solving in physics*

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

Kemenristekdikti, (2015). Peraturan Menteri Riset, Teknologi, dan Perguruan Tinggi Republik Indonesia No. 44 Tahun 2015 tentang Standar Nasional Pendidikan Tinggi. Berita Negara Republik Indonesia No. 1952 Tahun 2015. Jakarta: Biro Hukum dan Administrasi. Kemenristekdikti

Khanthavy, H., & Yuenyong, C. (2012). Examining Lao Student's Mental Model of Force and Motion. *European Journal of Social Sciences*. **35**, (3), 273-283.

Komariah, K. (2011). "Penerapan metode pembelajaran problem solving model Polyauntuk meningkatkan kemampuan memecahkan masalah bagi siswa kelas IX J SMPN 3 Cimahi". Yogyakarta: Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA. UNY.

Korsunsky, B. (2004). Ready, SET, Go! Aresearch-Based Approach to Problem Solving. *Jurnal The Physics Teacher*. **42**, 493-497

Lee, G., Shin, J., Park, J., Song, S., Kim, Y., dan Bao, L. (2005). Alternative conceptions, memory, & mental models in physics. *AIP. American Institute of Physics* Vol. 790, p.165

Mansyur, J. (2010). *Kajian fenomenografi aspek-aspek model mental Subyek lintas level akademik dalam Problem solving konsep dasar mekanika*. Desertasi Doktor pada Jurusan Pendidikan IPA SPs UPI Bandung: tidak diterbitkan.

Mariati, P.S., Betty, M.P., & Sehat, S. (2017). The problem solving learning model by using video recording on experiment of kinetimatics and dynamics to improve the students cognition and metacognition. *Jurnal Pendidikan Fisika Indonesia,* 13 (1), 25-32

Mark, J.B. (2012). *Understanding Key Concepts of Electric Circuits Student'use of Mental Models.* Thesis submitted for a Ph.D. Degree. University of York

Simanjuntak, M.P. (2012). *Pengembangan Model Pembelajaran Fisika Dasar Berbasis Problem Solving untuk meningkatkan Kemampuan Metakognisi dan Pemahaman Konsep Mahasiswa*. Disertasi Doktor pada Jurusan Pendidikan IPA SPs UPI Bandung: tidak diterbitkan

Supriyatman, Suhandi, A., Rusli, A., & Rusdiana, D., (2014). The Profile of Student Physics Education Mental Model in Electricity and Magnetism Concepts Using Problem Solving Test. *International Jounal of Science and Research.Vol. 3 Issue 8. p. 2093-2097*

Supriyatman, Suhandi, A., Rusdiana, D., Samsudin, A., & Wibowo, F.C. (2018). Problem-solving laboratory-based course development to improve mental model and mental-modeling ability. *Proceeding ICE-201,* Atlantis press: Advances in Social Science, Education and Humanities Research, volume 174

Tallman, J. I., & Henderson, L., (1999). Constructing mental model paradigms for teaching electronic resources. *Shcool Library Media Research. Research Journal of the American Association of school Librarians. Vol. 2, p. 1-10*

Thiagarajan, S., Semmel, D.S., & Semmel, M.I., (1974). *Instructional Development for Training Teachers of Exceptional Children.*Minneapolis Minnesota: Leadership Training Institute/ Special Education, University of Minnesota

Vosniadou, S., Skopeliti, I., & Ikospentaki, K. (2004). Modes of Knowing and Ways of Reasoning in Elementary Astronomy.*Journal Cognitive Development.* **19**, 203-222

Walsh, L. N., Howard, R. G., & Bowe, B. (2007). Phenomenographic Study of Students' problem solving approaches in physics. *Journal Physics Review Special Topics PER*. **3**, 020108

Wang, C.Y. (2007). The Role of Mental-Modeling Ability, Content Knowledge, and Mental Modelsin General Chemistry Students' Understanding about Molecular Polarity. Ph.D Dissertation Columbia: University of Missouri

Zacharia, Z & Anderson, O.R. 2003. The effects of an interactive computer-based simulation prior to performing a laboratory inquiry-based experiment on students' conceptual understanding of physics. *American Journal of Physics*. 71, (6), 618-629

STIMULATION OF PRESSURE ON LIQUID CONCEPT IN STAD LEARNING MODEL TO IMPROVE RATIONAL THINKING SKILLS AND LEARNING OUTCOMES OF STUDENTS

A.W. Nuayi*, Supartin, T.J. Buhungo

Physics Education Study Program, Faculty of Mathematics and Natural Sciences,
Universitas Negeri Gorontalo, Indonesia

ABSTRACT

The research aims to determine the effect of using cooperative learning model type STAD on learning science to students' performance in rational thinking skills and learning outcome. The point of view of this influence is seen from the presence or absence of improvement rational thinking skills activity of cognitive learning outcomes after treatment. The research used experimental method with the design One Shot Case Study and took place in SMPN 3 Gorontalo. The data obtained were students' performance in rational thinking skill and learning outcome gathered by observation sheet of students' activity and test sheet. The result show that increase in average score of students' performance in rational thinking in the third meeting compared to the first meeting by indicators of information digging, information processing, problem solving, and conclusion formulating. The overall result shows that the students' performance in rational thinking skills achieves good criteria; additionally, the students' learning outcomes achieve average score of 83.81, categorized as B (good).

ABSTRAK

Penelitian ini bertujuan melihat pengaruh penggunaan model kooperatif tipe STAD pada pembelajaran IPA terhadap kecakapan berfikir rasional dan hasil belajar kognitif siswa. Pengaruh ini dilihat dari ada atau tidaknya peningkatan aktivitas kecakapan berfikir rasional dan hasil belajar kognitif siswa setelah diberikan perlakuan. Penelitian ini menggunakan metode eksperimen dengan desain One Shot Case Study yang dilaksanakan di SMP Negeri 3 Gorontalo. Data yang diperoleh berupa aktivitas kecakapan berfikir rasional siswa dan hasil belajar kognitif yang dijaring dengan menggunakan lembar pengamatan aktivitas siswa dan lembar tes. Hasil yang diperoleh menunjukkan terjadi peningkatan rerata skor aktivitas siswa untuk kecakapan berfikir rasional pada pertemuan ketiga bila dibandingkan dengan pertemuan pertama untuk masing-masing indikator menggali informasi, mengolah informasi, memecahkan masalah dan membuat kesimpulan. Hasil penelitian secara keseluruhan menunjukkan perolehan dengan kriteria sangat baik untuk kecakapan berfikir rasional siswa, dan untuk hasil belajar kognitif siswa diperoleh rerata skor sebesar 83.81 dengan predikat B (baik).

Keywords: Learning Outcomes; Rational Thinking Skills; STAD

INTRODUCTION

Efforts to provide mastery of basic competencies to students in the learning process that lead to mastery of life skills need to be done, so that they have the courage to face problems in life and be able to solve these problems creatively. Research conducted by Mugambi and Muthui (2013) shows that life skills enable students to overcome life's problems and make important choices for their lives now and in the future. Other studies by Khera and Khosla (2012) show that by developing life skills oriented learning, in general can help students in translating knowledge, attitudes and values in healthy living behavior. Permendikbud 2013 states that the goal of science edu-

---
*Correspondence Address:
Jl. Jend. Sudirman No. 06 Kota Gorontalo, 96128
E-mail: wahidin.awn2023@ung.ac.id

cation emphasizes the understanding of the natural environment and natural resources that need to be preserved within the framework of physics, chemistry and biology. This indicates that science learning not only emphasizes the mastery of a collection of knowledge, but also a process of discovery that actively involves students and is oriented towards life skills that act as a tool to help students develop learning abilities (Kemendikbud, 2016).

Life skills that are intended are skills which refer to a variety of abilities of a person to be able to obtain life with success, happiness, and dignity in society. Setiorini and Munoto (2016) explained that life skills are the ability and courage to deal with life's problems, then proactively and reactively seek and find solutions to overcome them. According to the concept, life skills can be divided into five parts, namely:

(1) The ability to know oneself (self awareness), which is often called personal ability (personal skill). These capabilities include: (a) self-esteem as creatures of God Almighty, members of society and citizens, (b) realizing and grateful for the strengths and weaknesses that they possess as well as making them capital in improving their quality as individuals who benefit themselves and their environment

(2) Thinking skills. These skills include: (a) the ability to gather and find information, (b) the ability to process information and make decisions, (c) creative problem solving skills;

(3) Social skills which include: (a) communication skills with empathy, (b) the ability to work together, empathize, understanding attitude and the art of communication is not just conveying messages, but the content and arrival of messages accompanied by good messages, will foster a harmonious impression,

(4) Academic skills. Often called the ability to think scientifically (scientific method), including, among others, identification of variables, formulating hypotheses, and carrying out research, and

(5) Vocational skills (vocational skills) which are also called vocational skills, meaning that skills are associated with certain work fields contained in community (Ministry of National Education, 2007).

Science learning according to the 2013 Curriculum for junior high school / MTs is a learning integration of various concepts in integrated science subjects that use the transdisciplinarity approach. Through this integrated learning, making science as contextual lear-

ning enables students to actively seek, gather and discover scientific concepts and principles holistically, meaningfully and authentically both individually and in groups (Kemdikbud, 2016). Based on this description, it is expected that students can find the concept of science as a whole and authentic, so that they can have life skills and shape the personality of students who excel in solving various problems.

The reality in the field shows that the application of science education that integrates life skills so far has not been fully designed in learning. The achievement of these educational goals is only seen as a nurturant effect which is automatically formed along with the mastery of the subject matter. In addition, almost all schools found a learning pattern that was very product-oriented, so that the learning activities intended to foster the skills of educational processes and goals that included honesty, discipline, mutual tolerance, rational thinking, critical, etc. which were actually identical with skills. life in general or general life skills cannot be implemented (Depdiknas, 2006).

The results of interviews with science teachers in a number of junior high schools (SMP) and Madrasah Tsanawiyah (MTs) located in the city of Gorontalo indicate that the emphasis on life skills aspects in the science learning process, especially in the field of physics on the topic of pressure on liquids is not optimal. More than 85% of teachers stated that learning activities that integrate life skills that are identical with the skills of this process have not been included in the learning design. It was also stated that some of the students' skills were quite low, namely the students' skills in exploring and finding information, the ability to process information and make decisions, students' skills in process of concept discovery, students' communication skills (communicating experimental results), students' skills in applying mathematical operations and understanding mathematical language in solving science problems. This results in low student learning outcomes.

The results of the initial analysis carried out on students' rational thinking abilities (such as exploring and processing information, solving problems, and making conclusions) on the material pressure on liquids in SMP Negeri 3 Gorontalo, obtained results that when given a visionization of the phenomenon associated with sub-sections the topic of pressure on liquids (such as hydrostatic pressure, vessel contact and float, float and drowning events / Archime-

des' Law) there are 75% of students who have not been able to express what information they have obtained from the visualized phenomenon. Based on this situation it can be concluded that students have learning difficulties on the topic of pressure on substances, especially the pressure on liquids. This was confirmed by the results of the 2016/2017 Computer-Based National Examination (UNBK) published by the Ministry of Education and Culture (2017), the average score of students, especially in science subjects in a number of SMP / MTS throughout Gorontalo City, decreased compared to the academic year previous.

The decrease in the average score of students in 2016/2017 UNBK, especially in science subjects, based on the results of interviews with a number of science teachers, was due to teachers' difficulties in explaining abstract topics, including the topic of pressure on liquids. This is similar to what was stated by Loverude et al. (2003) that the material pressure on liquid and its application in everyday life is an abstract topic, so students experience problems in understanding the concepts taught in this topic. One of the impacts that will be caused by students' difficulties in understanding concepts is the low ability of students to solve problems (Johnson, 2012; Reddy & Panacharoensawad, 2017)

Based on the description above, the researcher tries to overcome it by implementing lifeskills oriented learning, especially rational thinking skills, by using cooperative learning model type Student Teams Achievement Division (STAD). The use of STAD type cooperative learning model was chosen due to it's advantages, namely helping students understand difficult concepts is also very useful to foster the ability to cooperate, critical thinking skills and communication skills (Sadieda & Avivah, 2011; Ernawati, 2014; Rahmawati et al., 2016).

Based on the advantages of the STAD type of cooperative learning model, the purpose of this study is to determine the effect of the use of STAD type cooperative learning model on science learning on rational thinking skills and student cognitive learning outcomes. This influence, seen from the presence or absence of an increase in the score of rational thinking skills activity and cognitive learning outcomes of students after being given treatment

METHOD

The research carried out is quantitative descriptive research and the method used is an experimental method with the One Shot Case Study research design, in which this design uses only one experimental class without comparison and also without the initial test. In this study treatment of the experimental class was given to determine the effect of the treatment (Arikunto, 2011).

The research was carried out in SMP N 3 Gorontalo 2016/2017 Academic Year with the population being all eighth grade students in 7 classes, grades VIII-A to VIII-G. The sample selection was determined by using Cluster random sampling technique or group sampling conducted by lottery method, so that class VII-IC was chosen as the experimental class. The instrument used in the study is rational thinking skills assessment sheet, which consists of student activity assessment sheets and test sheets that lead to indicators of rational thinking skills. Data collection techniques used observation and test methods.

The data obtained were analyzed quantitatively descriptive, by assessing the activities of students' rational thinking skills during the learning activities. This activity was observed by two observers with reference to the assessment rubric. The test results of students' rational thinking skills are interpreted according to the criteria for scoring and determining the predicate contained in the assessment guide book for SMP / MTs in the 2013 Curriculum, as listed in Table 1.

Table 1. Score Interval and Predicate of Students' Rational Thinking

Score Interval	Predicate	Annotation
> 90 – 100	A	Very Good
> 80 – 90	B	Good
≥ 70 – 80	C	Moderate
< 70	D	Poor

RESULTS AND DISSCUSSION

General Description of Research Implementation

In the initial stages of the implementation of learning activities by using the STAD type learning model on the topic of pressure on liquids presented the IPA phenomenon in the environment around them. Phenomenon given such as (1) the phenomenon of water entered in a bottle of mineral water, which then the bottle is perforated at varying levels, (2) the water

put in a teapot with different neck heights, (3) paper, safety pins and plasticine converted into various shapes, then put in a vessel filled with water. From these activities, students are asked to explore what information they can provide, both related to physical concepts and what physical quantities of the visualized phenomenon. Then from the information presented, students are then asked to process the information they get by asking questions / formulation of the problem. From the questions / formulation of the problems created by students this will be a guide for students in finding ways to solve problems.

The activity of asking students questions or problems about the phenomenon of science that they observe has the potential to train students to find and explore information, so they can process the information, and finally they can solve the problem well. This is in line with the facts put forward by Keles and Ozsoy (2009), that if students are able to express basic concepts well, then students will also have the ability to solve scientific problems well.

The next step in learning activities is that students work in groups, do practicums with the help of Student Worksheets (LKS). In this activity students are asked to carry out the practicum to answer the questions / problems they raised before. The solution to the problems they do through practical activities can be seen from the conclusions that they provide. In this session, the teacher as the facilitator gives comments, suggestions and input on students' conclusions, while strengthening the concept. Students who can solve problems properly and correctly are also shown by their ability to make conclusions. This is in line with the opinion of Zewdien (2014) that students who can convey ideas well, show that they are able to process the information they explore well, so that they can connect these ideas to be meaningful in a form of conclusion.

Overview of Results of Assessment of Students' Rational Thinking Skills

The results of assessment of life skills, especially students' thinking skills, are obtained through observing student activities during the learning process (for three meetings) which refers to indicators of rational thinking skills carried out by 2 (two) observers. The indicators of rational thinking consist of (1) the ability to gather information, (2) the ability to process information, (3) the ability to solve problems, and (4) the ability to make conclusions. General description of the results of the assessment of students' thinking skills at each meeting as presented in Table 2.

Based on the data presented in Table 2, which is then associated with Table 1, it can be seen that the giving of treatment is by using the STAD type cooperative learning model, students' rational thinking ability is in good criteria. This data is supported by the fact that most students (as indicated by the mode score) have a score of rational thinking skills of 80.16, 82.04, and 87.92 respectively at the first, second, and third meetings. In addition, the percentage of students who have a rational thinking skill score above the mean score reaches 52.38%. Based on these results it can be said that STAD cooperative learning has a positive impact on students, such as encouraging students to create a situation where one's success is determined by the success of the group.

In this learning, the teacher acts as a facilitator and students have the opportunity to be actively involved in every learning activity. Students are also more active in discussing with friends a group to solve problems, actively asking the teacher and being active to present the results of the discussion. Even so, there are still students at the first and second meetings on certain indicators that still get the title C (enough) and D (less) due to several factors such as class atmosphere that is less supportive, less optimal teachers in classroom management activities, so students are not focused , students who are not accustomed to conducting experiments cause the amount of time wasted explaining the steps of work and guiding students, as well as the differences in students' ability to absorb information conveyed by the teacher.

As stated by Ibrahim et al. (2010), that the mastery of teachers and students on the skills of planning and conducting experiments is the main provision needed to develop themselves and seek answers or solutions to problems faced in learning science in the classroom and in everyday life. In addition, the teacher plays a major role in the creator of a learning environment that is conducive to the growing development of students in mastering life skills.

Students' Rational Thinking Skills for each Indicator

Judging from each indicator of rational thinking proficiency also obtained an increase in scores of students' rational thinking skills as presented in Figure 1. Based on Figure 1, it ap-

Table 2. Overview of Results of Assessment of Students' Rational Thinking Skills

Meetings	Scores						
	Lowest	Highest	Average	Modus	Median	Varians	Deviation Standar
First	65.63	93.75	80.06	84.38	81.25	24.72	4.97
Second	75.00	93.75	85.42	87.50	84.38	12.51	3.53
Third	84.38	96.88	89.14	87.92	87.50	5.11	2.26
Average	75,00	94,79	84,87	86.60	84,38	14,11	3,59

pears that overall there was an increase in the average score of rational thinking skills at the third meeting for all indicators compared to the first meeting. The following is exposure to the results obtained for each indicator of rational thinking ability.

Ability to Gather Information

The aspect of rational thinking skills in the indicators of information gathering, as shown in Figure 1, shows that at the second meeting decreased by 0.78% from 76.79 to 76.19 and at the third meeting the average score increased to 89.29 or increased by 17.19%. This shows, that students have been able to gather information from reading, listening, seeing relevant phenomena and discussing and being able to emphasize as important information.
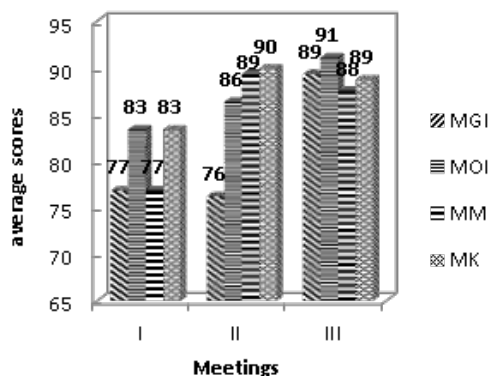
where: MGI: Exploring Information
MOI: Processing Information
MM: Solving Problems
MK: Making Conclusions

Figure 1. Average Score of Student Activity Refers to the Indicator of Rational Thinking Skills

Students' activities in exploring information at the first and second meetings are still low, in the sense that they are still in the sufficient category. The low score of these activities is due to students not yet accustomed to and rarely given the opportunity to read or look for reading material related to topics taught and practicum activities independently, so that students are not used to dig deeper information.

In this study, in the stage of presentation of material by teachers conducted through audio-visual shows and assisted by students' worksheet, students are given the opportunity to find and gather information based on the outlines of the information presented by the teacher. Then, students are given the opportunity to explain the findings of the information they have obtained.

Providing explanations and opportunities in searching for literature related to the topic of pressure being taught, making students accustomed to digging up information related to pressure topic from the literature/reading material presented. In addition, the material delivery activities always begin by explaining the learning objectives to be achieved at the meeting, as well as in the teacher learning process assisted by the media, demonstrations, questions or real problems that occur in everyday life.

The use of STAD type cooperative learning models in this study causes students to find information from various sources and learn from fellow group students. Not only smart students will always be active but all students. As stated by Slavin (2009: 143) that groups in STAD can increase students' confidence to find information from various sources and learn from fellow group students.

Furthermore, as stated by Arends (2008: 7-12) that one important aspect of cooperative learning is that in addition to that approach it helps improve cooperative behavior and better group relations among students, at the same time it will help students in academic learning. Thus it can be assumed that students with less learning abilities work side by side with those who have more abilities and these more capable groups benefit from the process of acting as tutors for their less fortunate friends. This is then suspected to be the cause of increasing students' ability to dig up information, as can

be seen from the reduced number of students with a C (enough) in each meeting from a total of 6 students at the first meeting to 3 students at the third meeting.

Information Processing Ability

In the learning process that takes place during the study, students are used to processing the information provided and what they get according to the concept well. This condition makes students' rational thinking ability on the indicator to process information at each meeting experience significant improvement.

The indicator processing information based on Figure 1, shows that there was an increase in the mean score from 83.33 at the first meeting, an increase of 9.29% to 91.07 at the third meeting. This average score increase shows that students process information through serious thinking and try to discuss the information. In this activity it is expected that the entire process of its activities can take place well, so that information can be entered in students' long-term memory as meaningful information.

In addition, an increase in the mean score of students for aspects of processing information, as well as in the aspect of exploring information, is thought to be caused by the use of the learning model used. The formation of a team in this learning makes students more enthusiastic in learning. The number of ideas that emerge, of course, will further enrich students' knowledge and understanding, so that students can improve processing information obtained.

Based on the findings obtained in this study, students who provide responses, ideas or input can help them to better process the information they obtain. So that students can straighten the wrong concept together. This is in line with what Morgan (1995) stated in his research, that in the STAD type of cooperative learning process indirectly there will be discussions between students both in one group and between groups, students are trained to express opinions/ideas, respect opinions/ideas friends, gather and find information, process information, make decisions, and solve problems.

The ability to solve problems

One of the stages in learning using the STAD model is grouping students into heterogeneous groups totaling 4-5 students. By grouping students into small groups gives an opportunity for them to discuss problems faced, exchange ideas, and obtain alternative solutions to problems that can be used. In addition, in small groups, students may be able to solve problems better than when working individually. Even though working together can take longer, the results of the study show that when working in groups, students are able to show better abilities in understanding the problem in more depth. This finding is in line with the results of Khan and Inamullah's (2011) study which suggests that STAD as a type of cooperative learning is able to meet students' needs in critical thinking, problem solving, and integrating knowledge with experience. For this reason, the use of cooperative learning models can improve the quality of learning because students can actively participate in a small group in learning activities to achieve the expected goals.

The results showed that on the problem solving indicator, the average score at the first meeting was 76.79, an increase of 16.28% to 89.29 at the second meeting. This data shows that students have been able to solve problems related to their duties in teaching and learning activities, although at the third meeting decreased by 2.00% to 87.5. The average decrease in scores at the third meeting was due to students being too preoccupied in teaching and learning, sometimes losing focus on the core problems that would be tried to be solved in the ongoing learning process. In addition, several students were observed to be in a hurry in completing the assignment, so they did not have time to review the results they had obtained.

As explained in Piaget's development theory, that the age of the eighth grade junior high school is the transition age from the concrete operational phase to formal operations, in this phase the majority of students will deal with the problems they face in a less systematic manner. One strategy that can be used to solve this problem is by giving students direct experience through practicum activities which are guided by student worksheets and the presentation of each group's activities makes students more able to process information, then solve problems faced so they can make conclusions from the topics being discussed (Nugroho et al., 2009).

Based on the findings of students in the field, the data obtained is that students often ask questions and express their ideas to friends in the group as well as to teacher things related to the practice questions that are on the student worksheet. Another step that can be done

is to train students not to make conclusions in a hurry and the teacher should provide more opportunities for students to brainstorm or brainstorm, so that students' ability to solve problems will increase (Nur & Wikandari, 2000).

Ability to Draw Conclusions

As with the problem-solving indicator, the average student score increased at the second meeting compared to the first meeting, with the average score at the first meeting of 76.79. Subsequently at the second meeting increased by 16.28% to 89.29, then at the third meeting decreased by 1.32% to 88.69. This data shows that students have attempted to make conclusions based on group opinions or relevant theories and with teacher guidance, students are able to solve problems related to their tasks in teaching and learning activities.

The problems that arise at this stage are the general condition of students who are less systematic in handling the problems they handle and the nature of students' hurry in completing the given task. Overall, based on the results of the assessment of the average score of students' rational thinking skills classically there was an increase in score of 10.18%, from 80.06 at the first meeting to 89.14 at the third meeting. The improvement of students' rational thinking skills is allegedly caused by treatment during learning activities. This happens because the STAD grouping has improved these aspects. When the process of discussion and problem solving takes place, students in one STAD group actively communicate with each other to solve the given problem. There was a discussion activity involving the measurement ability of each student so that the measurement aspect also increased. In addition, in solving problems together, students in the STAD group discuss to get the same perspective so that they can draw the final conclusions from the problems that have been solved. Thus, the concluding aspect also increases. This is in line with the results of research obtained by Ajaja and Eravwoke (2010) that cooperative learning, such as type STAD can increase student learning activities, such as in problem solving activities and drawing conclusions.

Based on the results of this study it can be seen that with the use of STAD type cooperative learning model can increase the average score of students for each indicator of rational thinking skills. Assessment of students' rational thinking skills in this study obtained optimal results with good and very good predicate. This is like the results obtained by Jufri and Djafar (2010) and Rahmawati et al. (2016) who succeeded in improving students' thinking skills by using the integration of STAD and TGT cooperative learning models. In line with this, Setiorini and Munoto (2016) also succeeded in improving students' life skills (including rational thinking skills) using STAD type cooperative learning models. In addition, as stated by Deming and Cracoline (2004) that the development of the quality of thinking skills, including the ability to think rationally can be done through the application of learning models that can actively involve in the process of thinking. So using the right learning model like the STAD type cooperative model can make students more active.

Student learning outcomes

In addition to observing the activities of students in thinking activities based on indicators during the learning process, at the end of the meeting an assessment was also given in the form of a written test. This test aims to measure students' knowledge after participating in life skills oriented learning activities in this case is rational thinking skills. The score of students' learning outcomes was measured using a 9-item description test which refers to the indicator of measured rational thinking skills, which consists of the C1-C6 cognitive domain with a maximum score of 75 as shown in Figure 2.
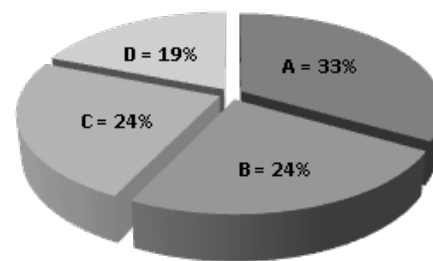
Figure 2. Score Percentage of Students' Rational Thinking Test

Percentage of junior high school students' post-test results on material pressure on liquid, from 21 students there were 33% of students (7 students) who received the title A (very good), 24% of students (5 students) who received the title B (good) and C (enough), and 19% (4 students) who received the title D (less). Based on the classical completeness criteria (KKM) that have been determined that is equal

to 75 and the determination of the predicate based on the assessment guidelines issued by the Ministry of Education and Culture in 2016 as presented in Table 1, the average score of student learning outcomes is 83.81 with the title B (good). However, from 21 students there are 4 students who have not yet completed. This means that classically it is categorized as complete, because based on the defined KKM which is 75, the percentage of students with a score above KKM reaches 80.95%.

The completeness of the material taught in this study was allegedly caused by the use of the STAD model. Therefore, the indicators and items arranged by the researcher can be said to have been mastered by students so that it can be said that life skills oriented learning, especially rational thinking skills by using STAD type cooperative learning models can help students to achieve learning completeness. This is supported by the results of research conducted by Setiorini and Munoto (2016) which states that the learning outcomes of students' knowledge competencies after being taught with cooperative learning models Type STAD obtain 100% completeness.

Judging from the increase in the average score of rational thinking skills and students 'cognitive learning outcomes that were learned by the STAD type cooperative model in this study, it was seen that there was a very strong relationship between students' rational thinking skills and learning outcomes. This very strong relationship is expressed by the results of testing the correlation between the scores of the results of the assessment of rational thinking skills with students' cognitive learning outcomes obtained a correlation coefficient of 0.88. In line with this study, the increase in learning outcomes obtained in this study is reinforced by the results of research conducted by Muliyani and Kurniawan (2014) which states that STAD type cooperative learning can improve student learning achievement, and there is a positive relationship between the ability to think with student learning outcomes cognitive domain.

CONCLUSION

The use of STAD type cooperative learning model can be used to improve students 'rational thinking skills and can complete students' cognitive learning outcomes classically for pressure material on the liquid. The results obtained showed an increase in the average score of student activity for rational thinking skills at the third meeting when compared to the first meeting, from categories with sufficient predicate at the first meeting, increasing to categories with good and very good titles at the third meeting. For students' cognitive learning outcomes, the mean of learning outcomes with the predicate B (good) was obtained, with 33% of students who received an A (very good), 24% of students who received the title B (good) and C (enough), and 19% get the title D (less). From these results it is suggested that in the future learning practice the teacher must pay more attention to these indicators.

ACKNOWLEDGMENTS

REFERENCES

Ajaja, O.P., & Eravwoke, O.U. (2010). Effects of Cooperative Learning Strategy on Junior Secondary School Students Achievement in Integrated Science. *Electronic Journal of Science Education*, 14 (1), 1-18.

Arends, R.I. 2008. *Learning to Teach* (Belajar Untuk mengajar). Yogyakarta: Pustaka Pelajar.

Arikunto, S. 2013. *Manajemen Penelitian*. Jakarta: Rhineka Cipta.

Deming, J.C., & Cracolice, M.S. (2004). Learning How to Think? *The Science Teacher Journal,* 71 (3), 42-47.

Departemen Pendidikan Nasional (Depdiknas). (2007). *Konsep Pengembangan Model Integrasi Kurikulum Pendidikan Kecakapan Hidup Pendidikan Menengah*. Jakarta: Balitbang Puskur.

Ernawati, T. (2014). Penerapan model pembelajaran Student Teams-Achievement Divisions (STAD) pada mata kuliah ilmu lingkungan sebagai upaya meningkatkan keaktifan dan prestasi belajar mahasiswa prodi pendidikan IPA FKIP Universitas Sarjanawiyata Tamansiswa Yogyakarta tahun akademik 2010/2011. *Jurnal Pendidikan IPA NATURAL*, 1 (1), 59-66.

Ibrahim, M., Nur. M, & Kasdi. A. (2010). *Dasar-Dasar Proses Belajar Mengajar. Surabaya*: Unipress Unesa.

Johnson, N. (2012). Teacher's and Student's Perceptions of Problem Solving Difficulties in

Physics. *International Multidiciplinary e-journal,* 1(V), 97-101.

Jufri, W., & Djafar, D.S. (2010). Efektivitas Pembelajaran Sains Berbasis Inkuiri dengan Strategi Kooperatif dalam Meningkatkan Keterampilan Berfikir Siswa. *Jurnal Pendidikan dan Pembelajaran,* 17 (2), 159-165.

Keles, O., & Ozsoy, S. (2009). Pre-Service Teacher's Attitudes Toward Use of Vee Diagrams in General Physics Laboratory. *International Electronic Journal of Elementary Education,* 1 (3), 124-140.

Kementerian Pendidikan dan Kebudayaan (Kemendikbud). (2016). *Panduan Penilaian Oleh Pendidik dan Satuan Pendidikan Untuk Sekolah Menengah Pertama*. Jakarta: Direktorat Jenderal Pendidikan Dasar dan Menengah, Direktorat Pembinaan Sekolah Menengah Pertama

Kementerian Pendidikan dan Kebudayaan (Kemendikbud). (2017). *Rekap Hasil Ujian Nasional (UN) Tingkat Sekolah*. Tersedia pada laman https://puspendik.kemdikbud.go.id/hasil-un/#

Khan, G. N. & Inamullah, M. H. 2011. Effect of Student's Team Achievement Division (STAD) on Academic Achievement of Students. *Journal of Asian Social Science*, 7(12), 211-215.

Khera, S., & Khosla. S. (2012). A study of core life skills of adolescents in relation to their self concept developed through YUVA School life skill programme: *International Journal of Social Science and Interdisciplinary Research,* 1 (11), 115-125.

Morgan, W.R., (1995). Critical Thinking What does That Mean? *Journal of College and Science Teaching*, 24 (5), 336-390.

Mugambi, M.M, & Muthui, R.K. (2013). Influence of structural context on implementation of secondary school life skills curriculum in Kajiado County Kenya: *International Journal of Education and Research*, 1 (03), 1-22.

Muliyani, R., & Kurniawan, Y. (2014). Profil Kemampuan Berfikir Kreatif dan Peningkatan Hasil Belajar Kognitif Siswa SMP melalui Model Pembelajaran Kooperatif Tipe STAD. *Prosiding Seminar Nasional Fisika dan Pendidikan Fisika* (*SNFPF*), 5 (3), 117-124.

Nugroho, U., Hartono., & Edi, S.S. 2009. Penerapan Pembelajaran Kooperatif Tipe STAD Berorientasi Keterampilan Proses. *Jurnal Pendidikan Fisika Indosesia*, 5 (2009), 108-112.

Nur, M., & Wikandari, P. R. 2004. *Pengajaran Berpusat kepada Siswa dan Pendekatan Konstruktivis dalam Pengajaran.* Surabaya: PSMS UNESA

Rahmawati, L., Jatmiko, B., & Raharjo. (2016). Pengembangan Perangkat pembelajaran IPA Menggunakan Model Kooperatif Tipe STAD dengan Strategi Talking Chips untuk Meningkatkan Hasil Belajar. *Jurnal Pendidikan Sains Pascasarjana Universitas Negeri Surabaya*, 5 (2), 968-974.

Reddy, M.V.B., & Panacharoensawad, B. (2017). Students Problem-Solving Difficulties and Implications in Physics: An Empirical Study on Influencing Factor. *Journal of Education and Practice*, 8 (14), 59-62.

Sadieda, L.U., & Aviyah, N. (2011). Penerapan model pembelajaran kooperatif tipe STAD (student Teams Achievement Division) melalui metode Team Teaching pada materi segiempat untuk melatih kecakapan siswa. *Jurnal Ilmiah Matematika dan Pendidikan Matematika,* 3 (1), 39-52.

Setiorini, D., & Munoto. (2016). Pengembangan perangkat pembelajaran berorientasi kecakapan hidup (life-skill) dengan menerapkan model pembelajaran kooperatif tipe student team achievement divisions (STAD) untuk meningkatkan hasil belajar pada mata pelajaran instalasi penerangan listrik di SMK Negeri 1 Nganjuk. *Jurnal PendidikanTeknik Elektro,* 5 (2), 445-452.

Slavin, R.E. 2009. *Cooperative Learning Teori, Riset dan Praktik*. Bandung: Nusa Media.

Zewdien, Z.M. (2014). An Investigation of Problem Solving in Physics Cources. *International Journal of Chemical and Natural Science*, 2 (1), 77-89.

NEUTRONIC DESIGN OF URANIUM-PLUTONIUM NITRIDE FUEL-BASED GAS-COOLED FAST REACTOR (GFR)

S. Novalianda[1*], M. Ariani[2], F. Monado[2], Z. Su'ud[3]

[1]Study Program of Physics, Faculty of Mathematics and Natural Sciences, Universitas Sriwijaya, Indonesia
[2]Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Sriwijaya, Indonesia
[3]Study Program of Physics, Institut Teknologi Bandung, Indonesia

ABSTRACT

This study presents the calculation results of the cell, and core Gas-cooled Fast Reactor (GFR) based fuel Uranium-Plutonium Nitride (U, Pu)N. Parameter survey results of calculations of the fuel cell consisting of a k_{inf}, burnup level, and the conversion ratio and for the calculation of the reactor core produce value k_{eff} during a refueling cycle. The calculation was performed by using a set of SRAC program by comparing three types of fuel cell designs. Reactor Design A based on natural uranium could not reach criticality because of $k_{eff} < 1$. Design B used the enrichment of uranium-235 by 9.5% to reach a critical condition at $k_{eff} > 1$. The critical state was also achieved by Design C utilizing natural uranium, and plutonium 5.5% result value $k_{eff} = 1.015$ in the first year of burnup and continues to increase 1.083 in the tenth year without refueling. Moreover, plutonium can replace the uranium enrichment process.

ABSTRAK

Penelitian ini menyajikan hasil perhitungan sel dan teras *gas-cooled fast reactor* (GFR) berbasis bahan bakar Uranium-Plutonium *Nitride* (U,Pu)N. Parameter Survey untuk hasil perhitungan sel bahan bakar terdiri dari k_{inf}, level *burnup*, dan *conversion ratio*. Sedangkan pada perhitungan teras reaktor dihasilkan nilai k_{eff} untuk satu siklus pengisian bahan bakar. Perhitungan dilakukan dengan menggunakan seperangkat program SRAC dengan membandingkan tiga jenis desain sel bahan bakar yang berbeda. Reaktor Desain A berbasis uranium alam tidak mencapai kekritisan karena $k_{eff} < 1$. Desain B menggunakan pengayaan uranium-235 sebesar 9,5% mencapai kondisi kritis pada $k_{eff} > 1$. Keadaan kritis juga dicapai oleh Desain C yang memanfaatkan uranium alam dan plutonium 5,5% menghasilkan nilai $k_{eff} = 1,015$ di tahun pertama *burnup* dan terus meningkat hingga 1,083 pada tahun kesepuluh tanpa pengisian ulang bahan bakar. Pemanfaatan plutonium sebagai bahan bakar dapat menggantikan proses pengayaan pada uranium.

Keywords: Burnup; Plutonium; Cell Core; Uranium

INTRODUCTION

The nuclear power plant is one of the energy sources to supply the electricity demand in Indonesia (Dewan Energi Nasional, 2014). The affordable operating cost and the absence of emission are the reason for the rapid growth of research and development in the nuclear power plant today (Giraldo et al., 2012). The attention on the development of Generation IV reactor, especially the helium Gas-cooled Fast Reactor (GFR) is needed presently (GIF, 2009). This GFR has a strength in its durability since it is operated in a closed fuel cycle using helium as a cooler. Also, it could

produce the hydrogen gas at the temperature of 850°C (Kelly, 2014).

The source of heat energy of the nuclear reactor is the use of Uranium as fuel. Uranium generates the energy through the fission reaction is shown by the equation 1 (Su'ud & Sekimoto, 2013)

$$\,^{1}_{0}n + \,^{235}_{92}U \rightarrow \,^{140}_{54}Xe + \,^{94}_{38}Sr + 2\,^{1}_{0}n + 200\ MeV$$

(1)
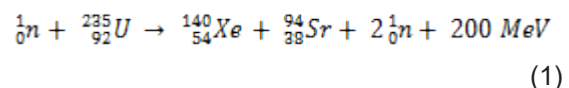
Uranium has three isotopes, i.e. U-238 (99.284%), U-235 (0.711%) and U-234 (0.005%). U-235 is fissile and can create neutron directly. However, the amount of U-235 is limited; so that an enrichment process is needed to boost the atom density. Also, U-238 is fertile which potential to be converted as fissile fuel by absorbing neutron in a reaction (Rooi-

*Correspondence Address:
Jalan Padang Selasa 542, Palembang, Indonesia 30121
E-mail: sari_novalianda@yahoo.com

jen, 2006).

The use of Uranium as a fuel of nuclear power plant will generate the electrical energy and side product at the end of its operation. The side product has a potency to be employed in another reactor to create more energy, for example, plutonium.

One of the fast reactor concepts to breed plutonium greater than its consumption is the Fast Breeder Reactor (FBR). Also, the waste of plutonium as a side product of FBR operation is beneficial as a fuel for other reactors (Walter & Reynolds, 1981).

Plutonium is generated from the absorbing reaction of the neutron in Uranium-238. Uranium-238 absorbs the neutron to be Uranium-239 which is converted to be Neptunium-239 naturally, and finally, it generates Plutonium-239. The chain of Uranium-238 burnup is presented in Figure 1 (Duderstatd & Hamilton, 1976).

Figure 1. The chain of Uranium-238 burnup

The fission reaction of Uranium in a nuclear reactor generates five Plutonium dominant isotopes, i.e., Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242. Only Pu-239 and Pu-241 are fissile which could be employed as a fuel for other reactors (Meyer et al., 2007).

The most important aspect in designing a nuclear reactor is the neutron analysis which is related to the neutron behavior in the reactor core (Ariani et al., 2013). The description of the physical condition of the neutron in the reactor core is explained by the multi-group diffusion equation as follows (Stacey, 2007):

The equation 2 describes the neutron behavior including population, distribution, energy, velocity, density, and the average neutron flux at each energy level.

$$\frac{1}{v_g}\frac{\partial \phi_g}{\partial t} - \nabla \cdot D_g \nabla \phi + \Sigma_{tg} \phi_g(r,t) =$$
$$\sum_{g'=1}^{G} \Sigma_{sg'g} \phi_{g'} + \chi_g \sum_{g'=1}^{G} v_{g'} \Sigma_{fg'} \phi_{g'} + S_{g'} \phi_{g'} \qquad (2)$$

Neutron population along the operation of the reactor will affect the fuel management and the fuel reduction during the process which is calculated by the equation of burnup as follows (Duderstadt & Hamilton, 1976).

$$\frac{dN_A}{dt} = -\lambda_A N_A - \left[\sum_g \sigma_{Ag}^A \phi_g\right]N_A + \lambda_B N_B + \left[\sum_g \sigma_{Ag}^C \phi_g\right]N_C \qquad (3)$$

Equation 3 is a burnup calculation related to the long-term change (day to the year) of the materials as a result of the nuclear reaction during the reactor operation. The burnup calculation is a basic of fuel management which consists of the calculation of reduction and isotope production as a function of time. Where $\lambda_A N_A$ represents the missing part as a result of radioactive decay, whereas $\left[\sum_g \sigma_{Ag}^A \phi_g\right]N_A$ is a missing part because of neutron trapping, $\lambda_B N_B$ is the additional nuclead A as a result of decay from B to A, and $\left[\sum_g \sigma_{Ag}^C \phi_g\right]N_C$ is the change from C to A through neutron trapping.

Another analysis to determine the neutron population is influenced by the effective multiplication factor (k_{eff}), i.e.:

$$k_{eff} = \frac{jumlah\ neutron\ pada\ generasi\ sebelumnya}{jumlah\ neutron\ pada\ generasi\ sesudahnya} \qquad (4)$$

Equation 4 has a rule of $k_{eff} = 1$ called as a critical condition where the number of neutron remains constant. $k_{eff} < 1$ is a subcritical condition where there is a decline of neutron number. $k_{eff} > 1$ is a supercritical condition where neutron number increases continually.

The objective of this research is to design the fast reactor GFR which can reach the critical condition, highly efficient, and durable.

METHOD

Research stages were started by setting up the design parameter of GFR as shown in Table 1.

Table 1. The design parameter of GFR

Parameters	Specification
Thermal Power	500 MWt
Fuels	Uranium-Plutonium Nitride (U, Pu)N
Enrichment U-235	1 – 9.5%
Plutonium	1 – 5.5%
Cladding	Stainless Steel (SS316)
Coolant	Helium
Volume Fraction: Fuel/Cladding/Coolant	60%/10%/30%
The diameter of pin pitch	1.4 cm
Core geometry	Silinder
Height/ Width of the active core	350 cm/ 240 cm
Reflector thickness	100 cm

Fuel cells consist of fuel, cladding, and coolant. Helium is one of the strong coolants compared to other inert coolants that cannot react with other matters (Novalianda et al., 2016).
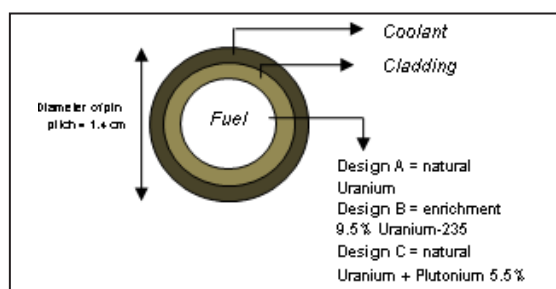
Figure 2. The geometry of the fuel cell

The fuel cell designed in this research were Design A with nature Uranium-based fuel cell, Design B with 9.5% Uranium-235, and Design C with nature Uranium added by Plutonium 5.5%. The geometry of the fuel cell is presented in Figure 2.

The mixture of fuel in the fast reactor which is based on the mixing of Uranium and Plutonium is Nitride. Nitride has a high melting temperature of 2500 °C and high thermal conductivity; thus, there is a possibility of obtaining the relatively lower temperature difference between the centers of fuel with the coolant. Nitride fuel is also flexible for fast reactors such as its high growing ratio, actinide burning, and the long-term terrace operation time (Meyer et al., 2007).

This research employed the program of *Standard Reactor Analysis Code* (SRAC) which has been developed by J*apan Atomic Energy Agency* (JAEA) since 1978 (Okumura et al., 2007). The flow diagram of the SRAC calculation can be seen in Figure 3.
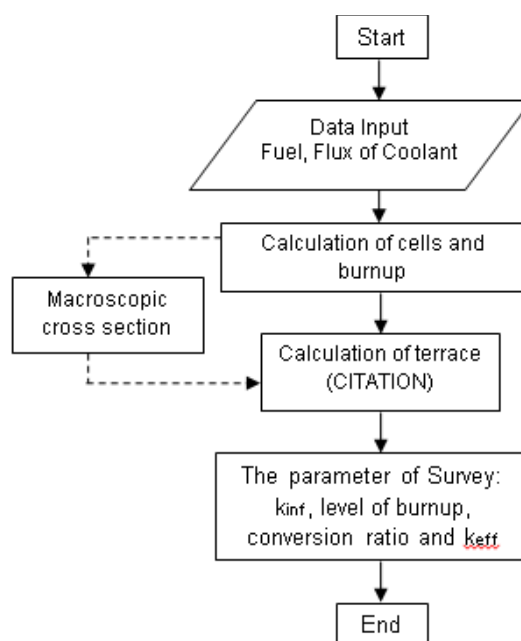
Figure 3. The calculation of the SRAC flow diagram

RESULTS AND DISCUSSION

SRAC calculation results in the GFR reactor were carried out by comparing the three reactor designs to the differences in fuel cells used. This fuel cell calculation is useful to determine the performance of one fuel cell for fifty years burnup so that it can later be used on the reactor core. Fuel cell calculations produce several survey parameters that have been determined, namely infinitive multiplication factor (k_{inf}), burnup level and conversion ratio.

The first survey parameter is k_{inf}. k_{inf} states the size of the increase or decrease in neutron flux, which is calculated in the absence of a leak factor (Hangbok et al., 2008). Changes in the k_{inf} value to the burnup time are shown in Figure 4.
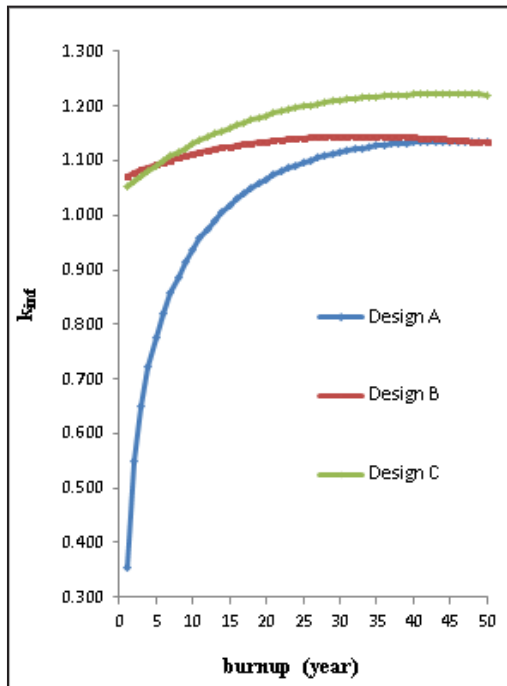
Figure 4. Infinitive multiplication factor (k_{inf}) to the change of burnup time

The Design A in Figure 4 shows the initial burnup k_{inf} value under the critical condition of 0.353 ($k_{inf} < 1$) because the number of neutrons produced is relatively small. It is because the fuel cell used is natural Uranium which has a fissile density of only 0.7% of the total. However, as time goes by, the critical condition can be achieved in the fourteenth year with a k_{inf} value of 1.005. The increase in k_{inf} occurs along with the increase in fission products generated during increased burnup time. Reactor criticality can be achieved in Design B and C with k_{inf} values at 1.071 and 1.076, respectively. Design B using Uranium-235 enrichment produced a fissile density of 9.5%, which means an increase of fissile material as much as 9.5% from the original 0.7%. This increase results in more neutrons produced than used neutrons. Likewise with Design C that uses plutonium at 5.5%, can reach critical conditions in the first year of burnup.

Burnup is defined as the total energy released per unit mass of fuel as a result of fuel combustion (Monado et al., 2013). Figure 5 shows the change in burnup level over burnup time, where the burnup level value continues to increase as burnup time increases. The burnup level value for Design A in the fiftieth year is 167 GWd / ton, meaning that in 1 ton of uranium fuel produces 167 GW of energy per day.

Design B also produces the same burnup level value as Design A, because the same fuel used is uranium. However, if each design is further examined, the average results are different. For example, Design A has a value of 0.085 GWd/ton and Design B at 0.084 GWd/ton. Moreover, Design C burnup level value is 161 GWd/ton with average 0.082 GWd/ton, where the value is smaller than the other two designs due to differences in the composition of the atom density input.
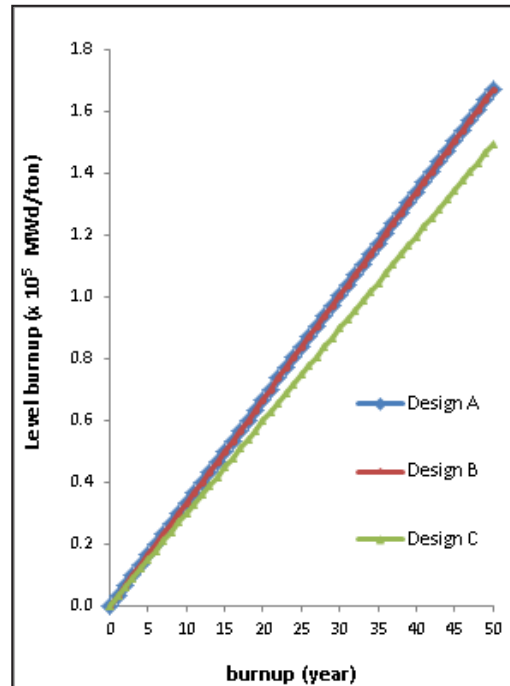

**Figure 5**. The change in burnup level

The conversion ratio (CR) states the ratio of the amount of fissile material produced with the fissile material consumed as shown in Figure 6. Design A, it shows the sharp decline of CR from 14.6 to 1.53. It is due to Design A which uses natural uranium with the fissile material used by 0.7% which is far less than the amount of its material. The decrease of CR value indicates that the breeder of fissile material will continue to decrease during burnup time because the number of neutrons produced will be far less than the neutrons used.

Design B has a CR value < 1 (0.99 to 0.95) which means that the reactor consumes more fissile material than the other designs. It is due to the reduced amount of Uranium-238 as a result of the enrichment of Uranium-235 by 9.5%. Nuclear reactors which are projected to be breeding reactors must have a CR value > 1 (Walter, & Reynolds, 1981). Thus, the reac-

tor only requires the intake of fertile material to be converted into fissile material. Furthermore, in Design C, the value of CR > 1 (1.79 to 1.24) due to two fissile materials used at the beginning of burnup namely Uranium-235 and Plutonium-239 so that the amount of fissile produced is much higher than the amount of fissile used.
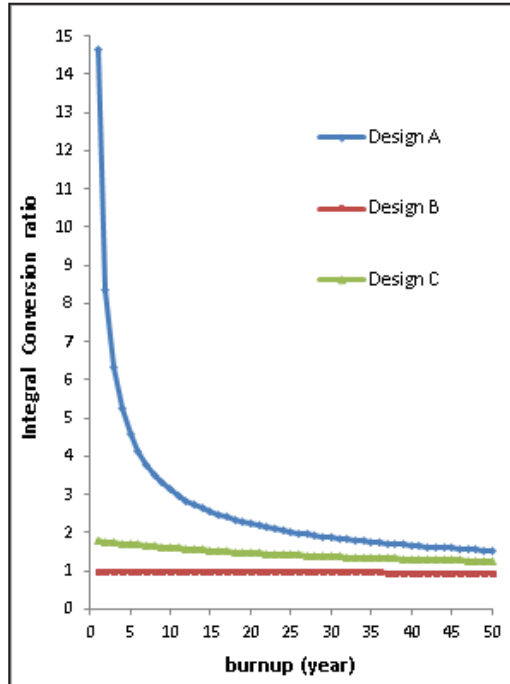
Figure 6. The change in conversion ratio to the burnup time
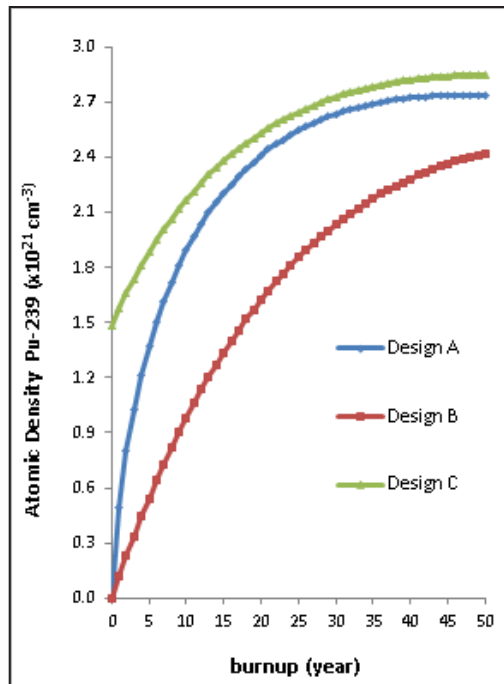
Figure 7. The change of Plutonium-239 atom density to burnup time.

During the burnup process, Uranium-235 will change to other elements. Likewise with Uranium-238 which is fertile will change into another element due to the fission reaction that occurs in the fuel cell. One of the fission products produced from Uranium-238 is Plutonium-239 (Figure 1). As shown in Figure 7, Design A has the change in density of Plutonium-239, which at the beginning of the fission reaction does not yet exist, until the burnup process runs. Plutonium-239 is created and will increase as long as the burnup process lasts for 2.7×10^{21} barn/cm. In Design B, the amount of Plutonium-239 will decrease to the 2.1×10^{21} barn/cm proportionally with the decrease in Uranium-238 density as a result of Uranium-235 enrichment used. Besides, the Design C shows the addition of Plutonium at the beginning of burnup process as much as 1.3×10^{21} barn/cm and will continuously increase the density of Plutonium-239 atom at the end of burnup time to the 2.1×10^{21} barn/cm.

Another design of GFR during burnup process shows the density of Plutonium-239 that has not been generated up to the tenth year of burnup time, due to Nitride Uranium natural fuel availability or without Uranium-235 enrichment done (Ariani et al., 2013).

The results of the calculation of the fuel cell will be used for the calculation of the reactor core, where the reactor core is composed of a collection of several fuel cells. This core calculation is carried out in one fueling cycle for ten years without refueling. The survey parameters observed were effective multiplication factors (k_{eff}), namely the ratio of the number of neutrons from one generation to neutrons in the next generation (Liem et al., 2008).

Figure 8 shows the change in k_{eff} value to burnup time. Design A has k_{eff} value < 1 that is 0.332 in the first year burnup, then the reactor has not reached its critical condition. Design B reactor has reached a critical state with k_{eff} value > 1 (1.008 to 1.051) with an excess reactivity of 0.031 %.

According to Su'ud and Sekimoto (2013), the criticality of the GFR reactor was also achieved in the GFR design with 800 MWt of uranium nitride fueled power using a CANDLE burnup strategy yielding a k_{eff} value of > 1 (1.002 to 1.007). Other studies on the GFR reactor design can also reach critical conditions at k_{eff} > 1 (1.001 to 1.050) using natural nitride uranium for ten years of refueling (Ariani et al., 2013).
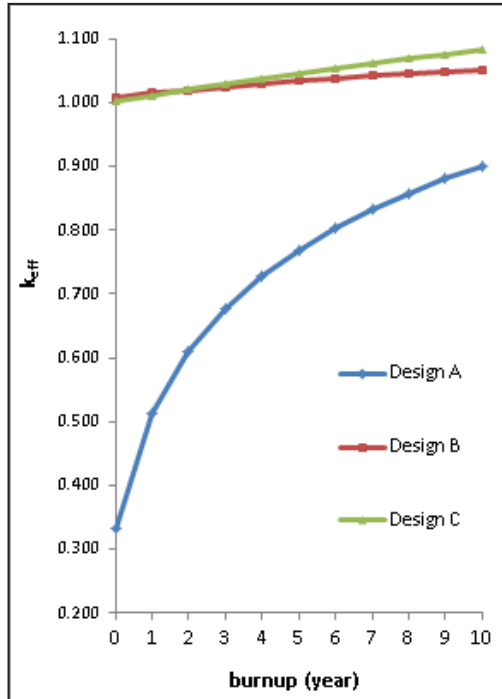
Figure 8. Effective multiplication factor (k_{eff}) to burnup time change

Excess reactivity states that there is an excess reactor reactivity due to an increase in k_{eff} value in the reactor core. In Design B, even though it reaches the critical condition of the reactor with a k_{eff} value > 1; however, the CR value is < 1 as shown in Figure 6. It means that the amount of fissile material produced is smaller than its consumption. This condition implies that the increase in burnup time, the fuel used will run out. Based on Design C, the reactor also reached the critical state at k_{eff} > 1 (1.015 to 1.083) with 0.047 % excess reactivity. This reactor can continue to operate due to the ratio of neutrons produced to the neutrons used is > 1.

CONCLUSION

The design of (U, Pu) N fuel-based GFR with a volume fraction consisting of 60% fuel, 10% cladding and 30% coolant produced a k_{eff} value > 1 (1.015 to 1.083) with an excess re-activity of 0.047 %. This reactor can operate for 10 years without a refueling process due to the ratio of neutrons produced to the neutrons consumed is > 1. The fission product of Uranium-238 is Plutonium-239 which can be reused as reactor fuel. The use of plutonium as a fuel can replace the enrichment process in Uranium-235.

REFERENCES

Ariani, M., Su'ud, Z., Monado, F., Waris, A., Khairur-rijal, Arif, I., Aziz, F., & Sekimoto, H. (2013). Optimization of Small Long Life Gas Cooled Fast Reactors with Natural Uranium as Fuel Cycle Input. *Applied Mechanics and Materials*, 260-261, pp 307-311.

Dewan Energi Nasional Republik Indonesia. (2014). *Outlook Energi Indonesia 2014*.

Duderstadt, J.J., & Hamilton, L.J. (1976). *Nuclear Reactor Analysis.* Department of Nuclear Engineering, The University of Michigan, Ann Arbor Michigan. JOHN WILEY & SONC, Inc.

GIF. (2009). GIF R&D Outlook For Generation IV Nuclear Energy Systems.Giraldo, S. J., D.J. Gotham., D.G. Nderitu., P.V. Preckel., & D.J. Mize. (2012). *Fundamentals of Nuclear Power*. State Utility Forecasting Group.

Hangbok, C., Rimpault, G., & Bosq, J.C. (2006). A Physics Study of a 600-MW (thermal) Gas-cooled Fast Reactor. *Nuclear Science and Engineering*.152(2), 204-218.

INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA). (1999). *Minimization of Waste from Uranium Purification, Enrichment and Fuel Fabrication,* IAEA-TECDOC-1115, Vienna.

Kelly, E. J. (2014). Generation IV International Forum: A decade of progress through international cooperation. *Progreess in Nuclear Energy.* 77, 240-246.

Laidler, K.J. (1993). *The World of Physical Chemistry*. Oxford University Press, Oxford.

Liem, P.H., Ismail, & Sekimoto, H. (2008). Small high temperature gas-cooled fast reactor with innovative nuclear burning. *Progress in Nuclear Energy.* 50 (2-6), 251-256.

Meyer, K. M., Fielding, R., & Gan, J. (2007). Fuel development for gas-cooled fast reactors. *Journal of nuclear materials.* 371, 281-287.

Monado, F., Z. Su'ud., A. Waris., K. Basar., M. Ariani & H. Sekimoto. (2013). Application of Modified CANDLE Burnup to Very Small Long Life Gas-cooled Fast Reactor. *Advanced Materials Research*. 772, 501-506.

Novalianda, S., Ariani, M., Monado, F., & Su'ud, Z. 2016. Studi Awal Perhitungan Sel Bahan Bakar Berbasis Uranium Oksida (UO_2) Pada Reaktor Cepat Berpendingin Helium. *Jurnal Lingkungan dan Pembangunan (Enviroment and Development)*. 2(1), ISSN 0216-2717.

Okumura, Teruhiko K., Kunio, K., & Keichiro, T. (2007). *SRAC2006: A Comprehensive Neutronic Calculation Code System*. Japan Atomic Energy Agency.

Rooijen, V**. (**2006). *Improving Fuel Cycle Design and Safety Characteristics of a Gas Cooled Fast Reactor.* IOS Press.

Stacey, M. W. (2007). *Nuclear Reactor Physics. Second Edition, Completely Revised and Enlarged*. WILEY-VCH Verlag GmbH & Co. KGaA.

Su'ud, Z., & Sekimoto, H. (2013). The prospect of gas cooled fast reactors for long life reactors with natural uranium as fuel cycle input. *Annals of Nuclear Energy*. 54, 58–66.

Su'ud, Z., Arbie, B., & Sedyartomo (2005). The Prospect of MOX Fuel Based Pb-Bi Cooled Small Nuclear Power Reactors'. *Progress of Nuclear Energy*. 47, 212-221.

Walter, E.A., & Reynolds, A. B. (1981). *Fast Breeder Reactors*. PERGAMON PRESS. New York/ Oxford/ Toronto/ Sydney/ Paris/ Frankfurt.

DESIGNING AND DEVELOPING RECHARGEABLE ALUMINIUM-ION BATTERY USING GRAPHITE COATED ACTIVATED CHARCOAL CORNCOB AS CATHODE MATERIAL

Fitriah*, A. Doyan, Susilawati, S. Wahyuni

Science Education Study Program, Postgraduate, Universitas Mataram, Indonesia

ABSTRACT

One of the renewable energy storage systems that can be used today is the aluminum ion battery. In this study, aluminum foil was used as anode, polyetylene polyprophylene (PE/PP) as separator, electrolyte from $AlCl_3$/[EMIm]Cl and graphite coated corncob, an activated charcoal, as cathode. Coating method of cathode materials was done by mixing both graphite and activated charcoal with varied composition 1:0.5, 1:1, 1:1.5, and 1:3. The coating process began by mixing the graphite and corncob with ethanol as a solvent for six hours, then heating in an oven at 80 °C for three days, gradual drying in a furnace at 350 °C for five hours and sintering at 600 °C for six hours. From this research, SEM results showed that carbon particles were evenly distributed, with spherical particles. The spherical shape was the main requirement of carbon formation in order to produce high energy. Based on the results, battery potential was 2.54 V with average of optimal capacity at a ratio of graphite and corncob activated charcoal 1:1.5 was 83.067 mAh/g. The highest efficiency was also at a ratio of 1:1.5 of 97.20%, because at this ratio, there was an increasing in percentage of element C 91.74%, greater than the percentage of element C on the other three cathode samples.

ABSTRAK

Salah satu sistem penyimpan energi terbarukan yang bisa digunakan saat ini adalah baterai ion aluminium. Pada penelitian ini digunakan aluminium foil sebagai anoda, polyetylene polyprophylene (PE/PP) sebagai separator, elektrolit menggunakan $AlCl_3$/[EMIm]Cl dan grafit terlapisi arang aktif tongkol jagung sebagai bahan katoda. Metode pelapisan bahan katoda dilakukan dengan mencampurkan grafit dan arang aktif dengan variasi komposisi 1:0,5, 1:1,1:1,5 dan 1:3. Proses pelapisan diawali dengan pencampuran grafit dan arang aktif tongkol jagung dengan ethanol sebagai pelarut selama enam jam kemudian pemanasan di oven pada suhu 80oC selama tiga hari, pengeringan bertahap di furnace pada suhu 350oC selama lima jam dan sintering pada suhu 600oC selama enam jam. Dari penelitian ini didapatkan hasil SEM menunjukkan bahwa partikel karbon terdistribusi merata, dengan bentuk partikel bulat (sphare).Sampelberbentuk bulat atau sphere merupakan syarat utama pembentukan karbon supaya dapat menghasilkan energi tinggi. Berdasarkan hasil uji baterai diperoleh potensial sebesar 2,54 Volt dengan rata-rata kapasitas optimal terjadi pada rasio grafit dan arang aktif tongkol jagung 1:1,5 sebesar 83,067 mAh/g. Efisiensi tertinggi juga terjadi pada rasio 1:1,5 sebesar 97,20%. Hal ini karena pada rasio 1:1,5 terjadi peningkatan persentase unsur C yakni 91.74% lebih besar dari persentase unsur C pada tiga sampel katoda yang lainnya.

Keywords: Aluminum Ion Battery; Corncob Activated Charcoal; Coating; Cathode; Graphite

INTRODUCTION

Battery is one of the need for human in energy storage. The development of renewable energy for power generation and transportation requires *energy storage* in the form of batteries.

Battery is electrochemical cells that produces a constant voltage from the electrochemical reaction. Battery is an electronic device that converts chemical energy into electrical energy. The battery has two electrodes in which a chemical reaction will take place by inoculating an electron. Both the anode and cathode electrodes are connected with a solution called

*Correspondence Address:
Jl. Majapahit 62 Mataram kode pos 83125
E-mail: fitriah.syarif@yahoo.co.id

the electrolyte where ion could move in it. The movement of these electrons will produce an electric current as a source of energy for electronic equipment (Sagir & Mohd, 2011).

On an aluminum-based battery, the anode is one of the most important components. Theoretically, the generated voltage depends on the metal type of its anode. This difference is based on the standard potential energy value of each metal (Vincenzo & Benedetko, 2014).

Aluminum acts as an anode on the battery, so this battery is named as an aluminum ion battery. The aluminum will oxidize resulting and electrons. Then, this electron will move towards the cathode. The movement of electrons to the cathode will produce electrical energy (Modesto & Julie, 2007). The aluminum battery is described as a battery that has high enough potential. This battery can be applied in various fields of application including in the military field. This is because aluminum batteries have a pretty good advantage such as light and rechargeable power (Rao et al., 1992)

One type of cathode used in aluminum-based batteries is graphite or three- dimensional grafit foam (Meng-Chang et al., 2015). In addition, other types of cathodes used in aluminum-based battery systems consist of three main components: porous carbon, catalysts and binder polymers (Jang et al., 2011).

This study used graphite coated with porous carbon contained in corncob activated charcoal as cathode. The porous carbon based on the structure pattern is an *amorphous* carbon material composed largely of free carbon and has an inner surface, thus having a high absorptive capacity (Alfathoni G., 2002). Activated carbon has a good absorption capacity to the solution and gas, activated carbon is one of the most frequently used adsorbents in the adsorption process. This is because the activated carbon has better absorption and surface area than other adsorbents (Walas, 1990). The nature of the activated carbon may be used as an electrode or as a gas absorbent medium to perform electrochemical processes on aluminum-based batteries (Yugang, 2013).

In addition, the use of activated charcoal as a coating of graphite material in anode making due to activated charcoal is one of the leading raw materials to increase storage capacity of a battery. So in this study, cathode was prepared with carbon source from amorphous carbon-coated graphite from corncob activated charcoal so that it can improve storage performence of aluminum ion battery.

The purpose of this study are: first, to know the effect of variations in graphite composition coated with corncob activated charcoal on microstructure of cathode material; second, to determine the effect of variations in graphite composition coated by corncob activated charcoal on quality of graphite coating; and the last, to know the influence of variation in graphite compostion coated by corncob activated charcoal on the performance of aluminum ion battery (battery capacity and battery efficiency)

METHOD

This research was an experimental research conducted at Analytical Technique Laboratory of Mataram University and Battery Laboratory of Physics Research Center (PRC) – Indonesian Institute of Science (IIS) Serpong Tanggerang Selatan. In this research, there were several stages of activity or workmanship, namely cathode material synthesis, material characterization, slurry making, sheet making, calendering and cutting Sheets, drafting to battery life, and battery performance testing.

Synthesis of Cathode Material

The first step in this research was the preparation of cathode materials for aluminum ion batteries. The synthesis process of graphite material was done by mixing method (graphite and corncob activated charcoal) with 50 mL ethanol on a hot plate at a temperature of $80^{\circ}C$ hot plate and spun at 200 rpm for six hours. Afterwards, the sample was stored in an oven $80^{\circ}C$ to remove the water content for three days until gel deposits was formed in the above prior to heat at 350° C for five hours called degradation process. Degradation process is a reaction of chemical change or decomposition of a compound or molecule into a simpler compound or molecule gradually. Heating for the release of hidrogen, so only remaining carbon in the sample. Next, resulting sample was crushed and reheated at 600° C sintering temperature for four hours, this was called the carbonization process. Carbonization is a process whereby the oxygen and hydrogen elements are removed from the carbon and will produce a carbon framework having a specific structure.

Material Characterization

The samples of the material have been made and characterized by using Scanning Electron Microscopy (SEM) Hitachi SU3500 brand with tungsten as the source of electron

to observe the morphology and particle size.

Aluminum Ion Battery Making

Battery making was done in several stages. The first stage, slurry making, prepared graphite coated corncob activated charcoal sample with variation of composition (1:0.5, 1:1, 1:1.5, 1:3), PVDF (Polyvinylidene Fluoride), AB (Acetyllene Black), and DMAC (NN Dimethyl Acetamid) according to the composition of 85%:10%:5% and DMAC ± 12 mL. PVDF powder acted as a binder, AB acted as an additive and DMAC acted as a solvent, then the hot plate to be used to make the slurry set with a temperature of 70° C with rotation of 150 rpm. First, mixed DMAC with PVDF at hot plate with magnetic stirrer inside beaker glass until clear then put AB into DMAC and PVDF solution slowly until well mixed. After being well mixed, inserted graphite coated corncob activated charcoal slowly and left mixed over hot plate until the desired slurry was formed ± 1.5 hours.

The second stage, sheet making, put Cu-foil over the doctor blade and vacuumed it, then Cu-foil was cleaned by acetone. The thickness of the doctor blade was measured with a thickness gauge of 0.2 mm and then poured slurry on Cu-foil little by little and doctor blade was run at speed of ± 6-7 rpm until Cu-foil was perfectly coated by slurry. After finished, then graphite anode sheet was dried on a dry box at temperature of 80° C until dried (± 1 hour).

The third stage, calendering, which include part of the sheet making process. Calendering was the process of pressing the sheets using a roll consisting of two tubes to ensure that the sheets did not fall out and were already sealed.

The fourth stage, *cutting,* the process of cutting the sheets for further used as an aluminum ion battery cathode. This cut was formed a circle with a diameter of 1.5 cm.

The last stage, battery assembly, prepared tools and materials needed then arranged in sequence from the base (can), spaser, anode, separator, and cathode. The used cathode was graphite coated with corncob activated charcoal and separator in the form of polyetylene polyprophylene *(*PE/PP). Dropleted electrolyte $AlCl_3$/[EMIm]Cl 2 M until the entire surface was exposed by electrolyte liquid, then placed spaser above it, next wave spring. Finally sealed with a seal and sealing chassing perfectly to cover it tightly. Left for one day before tested using battery analyzer (MTI)

Figure 1. Design of aluminum ion battery (coin cell).

Battery Testing Process

Battery testing was done using a battery analyzer (MTI) with the first step, put the battery in the terminal on the battery analyzer (there were 8 channels)**.** Then the BST8 software application (battery system test 8) was opened and ensured the software was connected to the battery analyzer. Next the battery parameters was set by right click and select startup. The parameters set included: constant current discharge/discharge current limit condition, constant current charge/current charging limit condition**,** Constant voltage charge/charging limit condition**,** Cycle/number of cycles and rest / break time**.** Then pressed Ok, the battery analysis process run to completion according to how many cycles were set.

RESULTS AND DISCUSSION

The graphite synthesis of corncob activated carbonated was carried out with four variations of composition ie 1:0.5, 1:1, 1:1.5, and 1:3 used as cathode materials on aluminum ion batteries. This research was conducted by several stages. The first stage was making of cathode from graphite coated corncob activated charcoal then identify its micro structure with SEM/EDX. The next step was the preparation of batteries include making slurry, sheet making, until battery assembly. Electrochemical characterization using MTI.

Characterization of microstructure using SEM (*Scanning Electron Microscopy***)**

The microstructures of graphite particles were characterized using Hitachi SU3500 SEM with *Energy Dispersive X-ray* (EDX). The results of SEM of the sample were shown in Figure 2 .

(a)

(b)

(c)

(d)
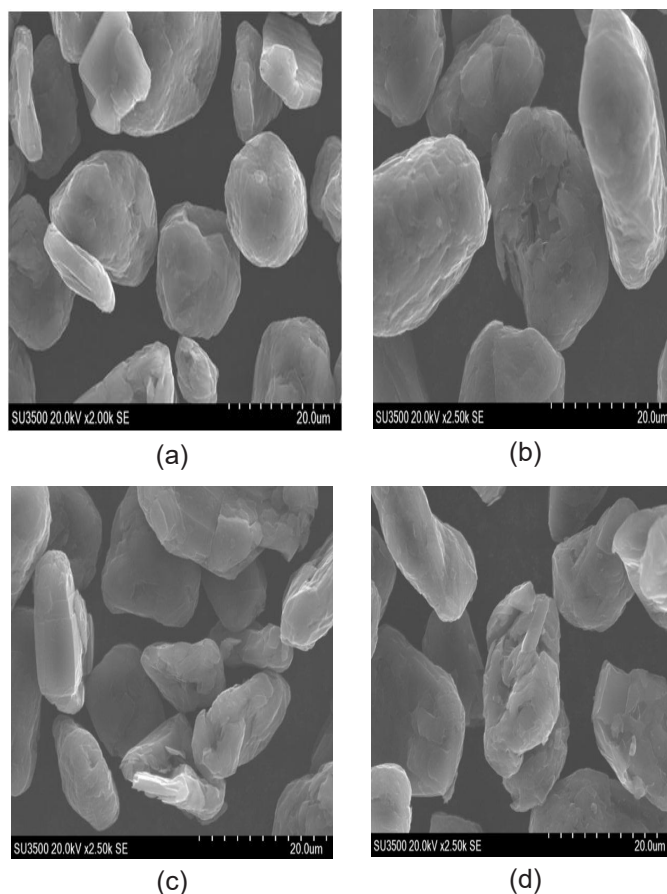
Figure 2. The result of SEM (a) graphite coated activated charcoal 1:0.5, (b) 1:1, (c) 1:1.5, and (d) 1:3.

Figure 2. shows photos SEM result of pure graphite and graphite coated activated charcoal with a variation of 1:0,5, 1:1, 1:3 composition. Observations were made at 2500 magnification times so that the morphology of the particles could be seen clearly.

Table 1. Average grain size of pure graphite samples and variations of graphite composition with activated charcoal .

Sample	Composition	Average grain size (μm)
A	1:0,5	108,518
B1	1:1	128,74
B2	1: 1,5	93,228
B3	1:3	103,161

Table 1. shows pure graphite with average grain size of 108.518 μm will change after coated with activated charcoal. The smallest grain size is present in the graphite sample which is coated activated charcoal on a 1:1 composition.

Table 2. The distribution of carbon (C) and oxigen (O) in pure graphite samples and graphite coated activated charcoal with composition 1:0.5, 1:1, 1:1,5, 1:3.

Sample	Content	Weight%	Atomic%
A	CK	89.45	91.86
	OK	10.55	8.14
B1	CK	91.35	93.36
	OK	8.65	6.64
B2	CK	91.74	93.67
	OK	8.26	6.33
B3	CK	83 .35	91.36
	OK	16.5	8.64

The result of SEM test on graphite coated activated charcoal with varied composition in photo scanning with 2500 times magnification. Spherical shape is the main condition of carbon formation for producing a high energy. Composite of metal elements with higher atomic numbers will result in lighter/brighter color than the constituent metal elements with lower atomic numbers.

The largest weight of carbon is shown in the variation of graphite composition with activated charcoal is sample B2 (1:1,5). This shows that in this sample formed the perfect carbonization at the time of *sintering* so that O more released and left only C, otherwise the sample B3 (1:3) has less distribution element C this shows that in this sample has not yet formed a perfect carbonization during *sintering* so that O has not much to detached.

Aluminum Ion Battery Performance Analysis Battery Capacity

The capacity of an aluminum ion battery with an initial potential of 2.54 V is shown by the following Figure 3.
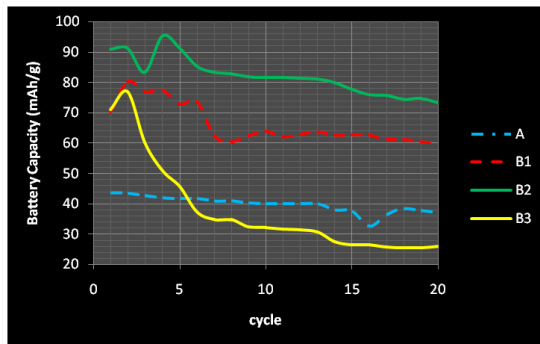
Figure 3 . Battery capacity per cycle.

The average battery capacity of sample A was 39.75 mAh/g, sample B1 was 65.95 mAh/g, sample B was 82.09 mAh/g, and samples B3 was 37.67 mAh/g. Figure 3 shows the greatest capacity occurring in sample B2 with a capacity of 95.37 mAh/g at the 4th cycle and its capacity drops to 73.203 mAh/g at the 20th cycle. This is proportional to the carbon percentage in Table 2. The lowest capacity occurs in the sample B3 of 25,509 mAh/g at the 18th cycle.

Battery efficiency

Battery efficiency is obtained from capacity test data during *charge* and *discharge process*. The value of battery efficiency was obtained from the comparison of discharge and charge capacity.

Average of battery efficiency in sample A was 96.53%, sample B1 was 68.74%, sample B2 was 97.20%, and sample B3 was 93.37% at 20 cycles. So the battery samples of A, B2, and B3 tend to have longer lifetime than battery sample B1, where battery B1 sample will run out faster in its application.

Figure 4 . The efficiency of the battery.

CONCLUSION

In this study we can conclude that the effect of variation in composition of graphite coated by corncob activated charcoal on the quality of graphite coating is shown by SEM analysis. The coating will change the average grain size and distribute the carbon particles well, with spherical shape.

The capacity of aluminum ion batteries with a potential of 2.54 V shows an increase that is proportional to the increase in the percentage of carbon on the cathode sample. Average of optimal capacity occured in the ratio of graphite and corncob activated charcoal 1:1.5 of 83.067 mAh/g. The highest efficiency also occurred at a ratio of 1:1.5, i.e. 97.20%.

Further research can be done by using variation of graphite composition with activated charcoal besides corncob active charcoal with the same composition that is 1:0,5, 1:1 , 1:1,5 and 1:3. Besides, higher sintering temperatures gives better results.

REFERENCES

Alfathoni, G. (2002). *Rahasia Untuk Mendapatkan Produk Mutu Karbon Aktif Dengan Serapan Iodin Di atas 1000 MG/G* : Yogyakarta.

Jang- Soo Lee, Sun Tai Kim, Ruiguo Cao, Nam-Soon Choi, Meilin Liu, Kyu Tae Lee, and Jaephil Cho, (2011), Metal- Air Batteries with Hight Energy Density: Li- Air versus Zn-Air, *Advanced Energy Materials* , Vol. 1, pp: 34-50.

Meng Chang, L., Ming Gong, Bingan Lu, Yingpeng Wu, Di-Yan Wang, Mingyun Guan, Michael Angell, Changxin Chen, Jiang Yang, Bing-Joe Hwang & Hongjie Dai, (2015), An Ultrafast Rechargeable Aluminum-Ion Battery, *Article in Nature*, Source: PubMed.

Modesto Tamez and Julie H. Yu, (2007), Aluminum - Air Battery, *Journal of Chemical Education*, Vol. 84, pp: 1936A - 1936B.

Rao, BNL, Alupower, Inc., Warren, NJ, USA, Cook, R., Kobasz, W., Deuchars, GD, (1992), Alu-

minum- Air Batteries for Military Applications, *Power Sources Symposium* , IEEE 35th International, pp: 34-37, dated 22 - 25 June 1992, Cherry Hiil, NJ, USA

Sagir Alfa & Mohd Rais Ahmad, (2011), *Metal - Air Cell and Method of Fabricating Thereof*, Patents, WIPO, WO 2011/139140 A2.

Vincenzo. C., and Benedetko. B., (2014), Materials Aspects of Zink-Water Batteries: A review, *Mater Review Sustain Energy* , Vol. 3, pp: 2-12.

Yugang Sun, (2013), Lithium Ion Conducting Membranes For Lithium - Air Batteries, *Nano Energy*, Vol. 2, pp: 801-816

SEISMIC HAZARD AND MICROZONATION STUDY OF TANJUNG REGION, NORTH LOMBOK (INDONESIA) USING MICROTREMOR MEASUREMENT

Syamsuddin[1]*, I. Ashari[2], M. A. Adhi[3]

[1]Physics Department, Universitas Mataram, Indonesia
[2]Civil Engineering Department, Universitas Mataram, Indonesia
[3]Physics Department, Universitas Negeri Semarang, Indonesia

ABSTRACT

Tanjung Region is one of the severely damaged areas by the Lombok earthquake on June 22, 2013. Therefore, to anticipate the similar events, it is necessary to perform microzonation in this region. Objective of this study is to map the distribution of the physical quantities related to the vulnerability of area included the frequency characteristics, amplification factor, and soil vulnerability index. The results showed that the value of the resonant frequency in this region ranged from 0.401 to 16.92 Hz. In general, the lower frequency was 0.40 to 5.91 Hz contained 87 data (71%) were located in the north of the region, which meant that that area has a high vulnerability. While based on the H/V amplitude and vulnerability index, the zone that suffered severe damage on the earthquake of June 22, 2013, showed a different uncertainty of amplification and vulnerability index value.

ABSTRAK

Wilayah Tanjung adalah salah satu daerah yang mengalami rusak parah akibat gempa Lombok pada tanggal 22 Juni 2013. Oleh karena itu, untuk mengantisipasi kejadian serupa, maka perlu untuk melakukan mikrozonasi di daerah tersebut. Tujuan dari penelitian ini adalah untuk memetakan distribusi besaran fisis yang terkait dengan kerentanan suatu daerah terhadap gempa bumi yang meliputi frekuensi respon, amplitudo getaran tanah dan indeks kerentanan tanah. Hasil penelitian menunjukkan bahwa nilai frekuensi resonansi di wilayah ini berkisar antara 0,401-16,92 Hz. Secara umum, frekuensi respon di daerah ini rendah yaitu 0,40-5,91 Hz dengan jumlah 87 data (71%) yang terletak di utara dari wilayah tersebut, yang berarti bahwa bagian utara wilayah memiliki kerentanan yang tinggi. Meskipun berdasarkan nilai amplitudo H/V dan indeks kerentanan, daerah yang mengalami kerusakan parah saat gempa 22 Juni 2013 menunjukkan pola amplifikasi dan indeks kerentanan yang sangat tidak biasa.

Keywords: Microtremor; HVSR; Nakamura; Seismic hazard; Microzonation; Tanjung; Lombok

INTRODUCTION

It has been observed that the damage as the result of the earthquake, is not only associated to a magnitude of the earthquake and its epicentral distance but also caused by the effect of the topographic and geological condition of the site. The reaction of the local geological conditions to the incoming seismic energy is known as the site response or local site effects (Fernandez & Brandt, 2000). For seismic hazard assessment, the site effect is typically represented by frequency of resonance and the associated ground motion amplification. Several methods such as array data analysis and horizontal to vertical spectral ratio (HVSR) refer to the site in estimating such parameters. On the other hand, the use of ambient vibration records for determining the fundamental resonant frequency has recently gained worldwide acceptance. It is well known that soil deposits amplify ground motion. The amplification depends on several factors including layer's thickness, the degree of compaction and age (Bonnefoy-Claudet, et al., 2006), (Syamsud-

*Correspondence Address:
Jl. Majapahit no. 62 Mataram, NTB 83125, Indonesia
E-mail: syamsuddin@unram.ac.id

din, Probopuspito, Sartohadi, Suryanto, & Adhi, 2014). One of the many reasons for choosing the ambient noise as widely accepted method by several researchers is that it allows the quick and reliable estimation of site characteristics of any area. Apart from being a cost-effective measure, it reduces time compared to evaluating site characteristics from an earthquake which has always been a time-consuming as well as an expensive process so far as the maintenance of equipment and human resources is concerned.

So many research in utilizing this H/V ratio estimation the fundamental frequency of ambient vibrations in urban environments (Lebrun, Hatzfeld, & Bard, 2001), (Guillier, Chatelain, Claudet, & Haghshenas, 2007), (Garcia-Jerez, et al., 2007). The proximity of fundamental frequency for resonance effects causes damages to a site of the existing man-made structures. Therefore, investigation of each site condition is an important step towards earthquake hazard mitigation (Rusilowati, Supriyadi, & Mulyani, 2012).

Indonesian Lesser Sunda, where Lombok Island is located has been proclaimed as one of the most tectonically active regions in the world. Two recent destructive earthquakes were one in 2004 and the other in 2013 had already ripped through this region. One of the most striking features of Lombok Island Region, Indonesia that most of its cities and densely populated settlements are located in the valley, sedimentary basins or hills, etc. The objective of this research is site characterization of Tanjung Region regarding resonant frequency, site amplification, etc. using H/V spectral ratio methodology (Nakamura Y. , 1989), (Nakamura Y. , 2000) as modified by (Bard, 1999).

Geology and Seismicity of the Study Area

Lombok Island is one of a small island in the archipelago of Nusa tenggara, Indonesia, tectonically is an area with very high seismic activity level. This is due to its position as the adjacent of the collision zone between the Eurasian and Indo-Australian Plate in the Indian Ocean where the Indo-Australian plate subduction rate is under the Eurasian plate of about 71 mm/year. As a result of the collision of the two plates, appear back arc thrust in the North of Lombok Island which is an active shallow earthquake generator from Bali to Flores and is very powerful and destructive. Based on the data from USGS, since 1973 to 2015 there has been more than 2400 earthquakes, and some

of them are destructive earthquakes (Fig. 1).

There were two recent destructive earthquake which occurred in the Lombok Island. First was the West Lombok earthquake on January 24, 2004, with the epicentre at 8.26°S and 115.79°E and depth of 33 km and 6.2 SR scale (IV MMI scale), this earthquake causing victims 30 people injured and 2,241 houses were damaged. The second one was North Lombok earthquake which occurred on June 22, 2013, with the epicentre at 8.43°S and 116.04°E (about 14 km north-west of Lombok Island) and depth of 10 km and 5.4 SR scale (III-IV MMI scale) with victims 44 people injured and 5,370 houses were damaged (Anonym, 2013).
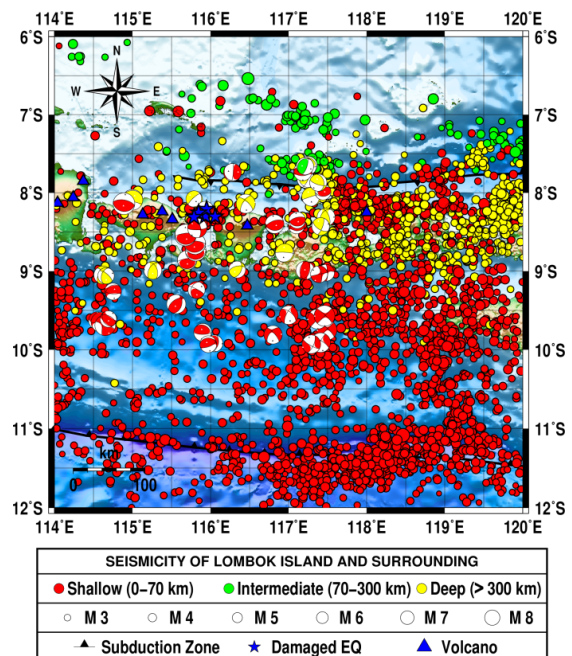

Figure 1. Seismicity map of Lombok Island and surrounding region.
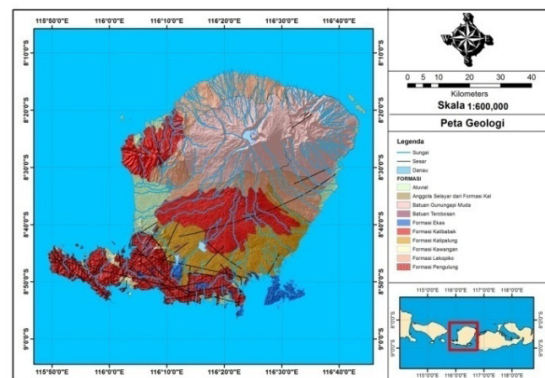

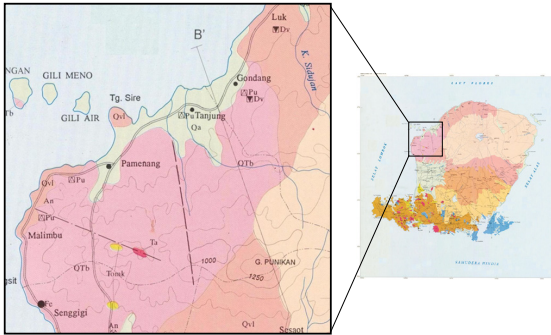**Figure 2**. Geological map of Lombok Island.

Figure 3. Location of survey.

The lithology of Lombok Island is composed of sediment which is relatively young with Tertiary to Quaternary age (Manga, Atmawinata, Hermanto, & Amin, 1994). Rocks in Lombok island are dominated by volcanic rocks, consisting of volcanic breccia, lava, and sandstone. Some places are covered by sediment quarter which is relatively young and unconsolidated (Fig. 2). In the eastern part of Lombok Island, the tertiary rocks forms are composed of breccias, lavas, tuffs, etc. In the west, which is an alluvial area, the rock arrangement is composed of alluvial or loose rock such as sand, gravel, and mud, where in the northern part of the rock area, consists of Quaternary volcanic rocks precipitated from Rinjani volcano. The rocks are loose, especially around Rinjani Volcanic area. The sediment layer is quite thick, which cover nearly two-thirds of the Lombok island (Agustawijaya & Syamsuddin, 2012).

METHOD

Microtremor Survey

In this study, microtremor measurements was carried out in the Tanjung Region, North Lombok District (Fig. 3). Measurements were made for 15 days (June 25 to July 9, 2015) with the number of points as much as 123 point of measurement. The model of Seismometers used was the LE-3D/20s with three components of speed sensor (Lennartz Electronic) connected to data logger series DI-710 (Data Instruments) along with Windaq Professional software as the acquisition partner. The utilized speed sensors had a natural frequency of 0.05 Hz and could measure the vibration of the three components of one vertical and two horizontal directions. The frequency response to the tool was 0.05 to 40 Hz. Data recording was performed with a sampling rate of 100 samples per second with a duration measurement of 20 to 60 minutes. The survey area on-gird with

a spacing of 500 meters. The position of each measuring point was determined by GPS.

The seismometer was placed on a concrete or tar-sealed surface, but in cases where only grass or soft surface soil was available, a removable concrete pad was used as a base to remove any resonance involving the seismometer and the ground (see fig. 4).

Figure 4. Setting of seismometer at ground surface

To ensure the reliability of noise recording, the guidelines proposed by (Koller, et al., 2004) was used as guidance in the framework of SESAME. Besides, quiet environment & good weather condition had been the prime requisite for executing this data acquisition process. At each field measurements location, the sheet was filled in which described the time, date, operator name, coordinates, etc. of the area onset and the duration of the measurement.

Microtremor H/V analysis

Data were processed by applying the horizontal to vertical (H/V) spectral ratio method, using the GEOPSY software package (www.geopsy.org). In pre-processing, all data were converted to SAF format (SESAME ASCII Format). HVSR at each site was computed with the following steps (Duval, et al., 2004): (1) Offset removal (baseline correction). Since similar sensors are used for all the three components, therefore no instrumental correction has been applied; (2) filtering the band-pass with a frequency ranging from 0,02 to 20 Hz; (3) Determining the stable time windows in the 20 s length and removing time windows contaminated by transients using an anti-trigger algorithm. This assured that only the coherent

constituent of microtremors were included and the transient was discarded. This was performed to obtain the comparison between short term average ('STA', the average level of signal amplitude over a short period of time, 1 s) and long-term average 'LTA' (the average level of signal over a much longer period of time, 30 s). Only windows with threshold ratio STA/LTA from 0.3 to 2.5 was used for computing the H/V. (4) For each time window, a 5% cosine taper function was applied on both sides of the window signal of the Vertical (V), North-South (NS) and East-West (EW) components; (5) The Fourier spectra were calculated for each time windows of the three components to obtain the three spectral amplitudes using the Fast Fourier Transform (FFT) and smoothed with using Konno-Ohmachi filter with constant bandwidth of b=40 (Konno & Ohmachi, 1998). (6) Finally, the Fourier amplitude ratio of the two horizontal Fourier spectra and one vertical Fourier spectrum were obtained using Equation (1):

$$r(f) = \frac{\sqrt{S_{NS}(f) \times S_{EW}(f)}}{S_Z(f)} \qquad (1)$$

Where r(f) is the horizontal to vertical (H/V) spectrum ratio, SNS(f), SEW(f) and SZ(f) are the Fourier amplitude spectra in the NS, EW and Vertical directions, respectively.

After obtaining the H/V spectra for the selected segments of the signal, the average of the spectra was obtained as the H/V spectrum for a particular site. The same procedure was repeated at all locations. The peak of the H/V spectral plot showed the predominant frequency of the site and the H/V amplitude. Additionally, calculation of standard deviation for each point was performed earlier.

RESULTS AND DISCUSSION

The main results obtained in this study is the resonance frequencies (f_0) of the site-sedimentary geology (site-soil columns) and the correspondence of relative site-amplification factor (A_0) derived from the amplitude of spectral ratio values.
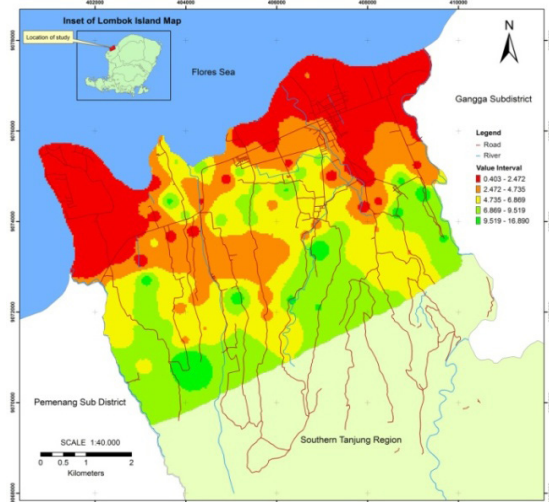
Figure 5. Map of the resonance frequency (f_0) for Tanjung Region.

Figure 5 shows a map of the resonance frequency of land vibration in the of Tanjung Region, North Lombok. The ground vibration frequency values was corresponded with the thickness of sediment constituent in the region. Based on the map showed that the value of the vibration frequency of the soil ranged from 0.403 Hz to 16.890 Hz.

The vibration frequency in low land was f0= 0.403-2.471 Hz, symbolized by the red color. Therefore, the value of the frequency was inversely proportional to the value of the ground vibration period, as it could also be regarded as ground vibrations with a very long period, the very low vibration frequency of the soil was generally associated with very thick sediment. The low vibration frequency with f0 = 2.471-4.735 Hz, which was symbolized by the brown color, associated with long periods of vibration, which could be interpreted as a thick sediment. The frequency of the vibration to the value of f0 = 4.735-6.869 Hz, symbolized by the yellow color, associated with periods of moderate ground shaking, interpreted as a rather thick layer of sediment. High-frequency vibration to the value f0 = 6.869-9.519 Hz, which was symbolized by the light green color, associated with short periods of ground vibrations, which could be interpreted as a thin sediment. The very high vibration frequency with a value f0 = 9.519-16.890 Hz, which was symbolized by the green color, it is associated with a very short period of vibration, which could be interpreted as a very thin sediment.
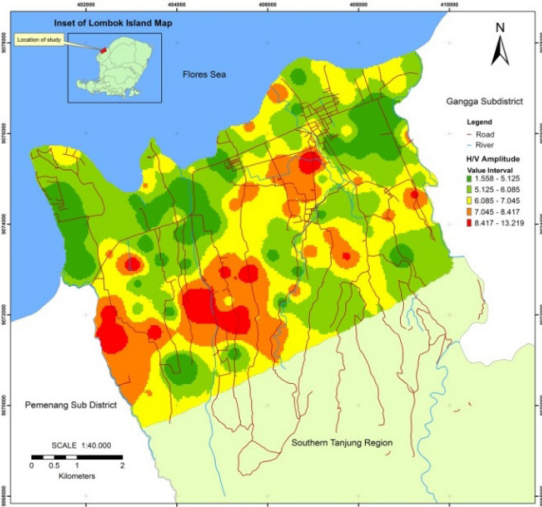
Figure 6. Map of the amplification factor (A_0) for Tanjung Region.

Figure 6 showed the map of the ground-shaking amplification in the Tanjung Region, North Lombok. The amount of vibration was related to the nature of the soil compaction or hard-soft sediments that made up the region. The amount of ground vibration amplification ranged from 1.558 to 13.219. To simplify the analysis and interpretation, the vibration amp-lification value of land in this map was divided into five classes as follow: very low Amplificati-on of ground vibrations with A0 = 1.558-5.124 represented by the green color, associated with very compact sediment. Lower amplification of ground vibrations with A0 = 5.124-6.085, de-picted with light green color, was associated with hard sediment. Amplification of ground vibrations with A0 = 6.085-7.045, rep-resented by the yellow color was associated with soft to hard sediment. High amplification of ground vibrations with A0 = 7.045-8.417, illustrated by a brown color, associated with soft sediments. Very high amplification ground vibrations with A0 = 8.417-13.219, which was depicted in red, associated with a very soft se-diments that generally consist of soft clay.

Figure 7 showed the map of the vulnera-bility index in the surface in the Tanjung Regi-on, North Lombok. The value of land vulnera-bility index was related to sediment thickness and compacting properties or hard-soft sedi-ments in the region. The value of this land vul-nerability index ranged from 0.169 to 95.873. To simplify the analysis and interpretation, the vulnerability index value of land in this map was divided into five classes as follow: (a) The va-lue of vulnerability index of very low with Kg =

0.169-12.226, represented by the green color, was generally associated with very thick and very hard sediments. (b) The values of vulne-rability index of lower land with Kg = 12.226-23.907, were depicted with light green color, generally associated with thick and hard sedi-mentary. (c) The value of vulnerability index of land with Kg = 23.907-39.732, which was de-picted in yellow, associated with thick and hard sediment. (d) The value of vulnerability index of land with Kg = 39.732-59.701, which was de-picted with a brown color, associated with thin and soft sediments. (e) The value of vulnera-bility index of land with Kg = 59.701-95.873, which was depicted in red, associated with very thin and soft sediments.
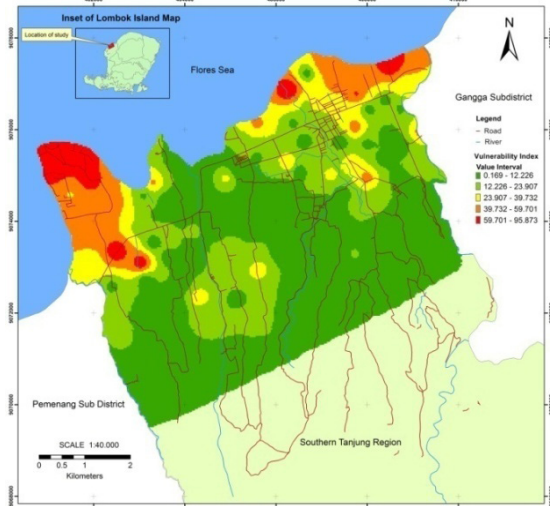
Figure 7. Map of the seismic vulnerability index (K_0) for Tanjung Region.

CONCLUSION

Based on the description of the results and discussion above, some conclusions can be state that the values of the natural ground frequency ranged between 0.403 Hz to 16.890 Hz. The distribution pattern of the natural fre-quency value of ground in of Tanjung Region tend to have a regular pattern where the nort-hern part of the zone has the lower value and in the southern area has a high-frequency value.

The value of amplification of land in Tanjung Region ranged from 1.558 to 13.219. The distribution of the value of the amplifica-tion tend to have a regular pattern where the northern zone had a lower value (safer to be occupied), while the southern part of the area has a higher value of amplification (less safe for occupancy).

High amplification – very high regions zones that suffered severe damage when an earthquake ocurred in Lombok on June 22, 2013, namely Gol Village and Orong Kopang Village in Desa Medana and Karang Nangka village, Tanjung.

The value of vulnerability index of the land in Tanjung Region ranged from 0.169 to 95.873. The value distribution of the vulnerability index of the land tend to have a regular pattern similar to the map of northern part where the amplification value in this zone was low, while the southern part of the region had a higher ground vulnerability index. When compared to the building's damage pattern caused by the earthquake in Lombok on June 22, 2013 to, the vulnerability index map also had a positive correlation.

There was a positive correlation between the map of ground shaking amplification and ground susceptibility index with a pattern of damage caused by the earthquake of Lombok on June 22, 2013.

ACKNOWLEDGMENTS

REFERENCES

Agustawijaya, D. S.;& Syamsuddin. (2012). The Development of Hazard Risk Analysis Methods: A Case Study in Lombok Island. *Dinamika Teknik Sipil , 12* (2), 146-150.

Bard, P. (1999). Microtremor measurements: a tool for site affects estimation? *Proc. 2nd International Symp. on Effect of Surface Geology on Seismic Motion*, (ss. 1251-1279). Yokohama, Japan.

Bonnefoy-Claudet, S.;Cornou, C.;Bard, P. Y.;Cotton, F.;Moczo, P.;Kristek, J.;ym. (2006). H/V ratio: a tool for site effects evaluation. Results from 1 D noise simulations. *Geophys. Jour. Int. , 167*, 827-837.

Duval, A. M.;Vidal, J. -P.;Meneroud, S. A.;De Santis, F.;Ramos, C.;Romero, G.;ym. (2004). Site effect determination with microtremors. *Pure Appl. Geophys. , 158*, 2513-2523.

Fernandez, L. M.;& Brandt, M. B. (2000). The reference spectral noise ratio method to evaluate the seismic response of a site. *Soil Dynamics and Earthquake Engineering , 20*, 381-388.

Garcia-Jerez, A.;Navarro, M.;Alcala, F. J.;Luzon, F.;Perez-Ruiz, J. A.;Enomoto, T.;ym. (2007). Shallow velocity structure using joint inversion of array and h/v Spectral ratio of ambient noise: The case of Mula Town (SE of Spain). *Soil Dynamic and Earthquake Engineering , 27*, 907-919.

Guillier, B.;Chatelain, J.;Claudet, S. B.;& Haghshenas, E. (2007). Use of ambient noise: From Spectral amplitude variability to H/V Stability. *Jour. Earth. Eng. , 11*, 925-942.

Koller, M.;Chatelain, J. -L.;Gullier, B.;Duval, A. M.;Atkan, K.;Lacave, C.;ym. (2004). Practical user guideline and software for the implementation of the H/V ratio technique on ambient vibrations: measuring the conditions, processing method and results interpretation. *13th World Conference on Earthquake Engineering.* Vancouver, B.C., Canada.

Konno, K.;& Ohmachi, T. (1998). Ground motion characteristics estimated from spectral ratio between horizontal and vertical components of microtremor. *Bull. Seism. Soc. Am. , 88*, 228-241.

Lebrun, B.;Hatzfeld, D.;& Bard, P. Y. (2001). A site effect study in urban area: experimental results in Grenoble (France). *Pure and Appl. Geophys. , 158*, 2543-2557.

Manga, A.;Atmawinata, S.;Hermanto, B.;& Amin, T. C. (1994). *Peta Geologi Lembar Lombok, Nusa Tenggara.* Jakarta: Direktorat Jendeal Geologi dan Sumberdaya Mineral, Departemen Pertambangan dan Energi.

Nakamura, Y. (1989). A method for dynamic characteristics estimation of subsurface using microtremor on the ground surface. *Q.R. Rail. Tech. Res. Inst.* , 25-30.

Nakamura, Y. (2000). Clear identification of fundamental idea of Nakamura's technique and its Applications. *Proc. 12th World Conference on Earthquake Engineering.* Auckland, New Zealand.

Rusilowati, A., Supriyadi, A., & Mulyani, S.E.S (2012). Mitigasi Bencana Alam Berbasis Pembelajaran Bervisi Science Environment Technology and Society. *Jurnal Pendidikan Fisika Indonesia*, 8, 51-60.

Syamsuddin;Probopuspito, K. S.;Sartohadi, J.;Suryanto, W.;& Adhi, M. A. (2014). Local Seismic Hazard Assessment of the Mataram City, Indonesia Based on Single Station Microtremor Measurement. *International Conference on Mathematics, Science, and Education* (ss. P45-P49). Semarang: FMIPA UNNES.

THE GUIDELINES OF CONSTRUCTING ARTICLE

The article is as a result of research or a conceptual study in physics education or in applied physics subject. The article can be written in bahasa Indonesia or in English. Constructing an article can be done by using word processor "Microsoft Word", by typing it in Arial size 11, space 1,5, margin 2 cm, formula and equation well typed with Microsoft Equation, and the total pages are 14-18 pages, using A4 format page, in one column. The article can be sent via e-mail or online submission.

The Systematic of Constructing Article
Title
- The title is written in both Indonesian and English.
- The title of the article is informative. Not too complex nor too simple (5-12 words).
- It contains variables which can be researched and describes the whole content of the document.
- It does not contain mathematics formulas or non-standard abbreviation.
- The writer's name (without academic title), completed by name and institution name, along with e-mail can be typed below the title of the article.

Abstract and Keywords
- The abstract is typed briefly and densely about the most important ideas.
- The abstract contains the problems and or the research objectives, the research methodology, and the result of the research.
- It must be typed in both Bahasa and English, containing of 125-150 words.
- Keywords contains the main and important words, 3-5 words.

Introduction
The Introduction part is integratedly explained in the form of paragraphs with the length of 15%-20% of the article. It contains of:
-The Background or the Research Rational
-The Literature Reviews
-The Research Objectives

Method
- The Method part is written in the length of 15%-20% of the article. The result is the main part of the scientific article containing:
- The research programs
- The Methods of Data and Sources Collection
-The Methods of Analysing Data

Results and Discussion
- The Result and The Analysis is elaborated in the length of 60%-70% of the article. The Result is the main part of the scientific article. It contains of:
- The result of the data analysis
- The hypotheses test
- It can be completed by applying tables or graphics, in order to make it clear verbally. Meanwhile, The Discussion is the main part of the whole article's contents; it consists of min. 8 pages.
The objectives of the Discussion are:
- To answer the research problems
- To interpret all findings
- To integrate all findings from the research to the collection of available knowledges
- To arrange the new theories or to modify the available theories.

Conclusion
- It contains of the conclusion and the suggestion, max. 1 page
- The conclusion contains the answer of the problem questions.
- All Suggestions are reflected to the result of the research and are practical steps; it also mentions to whom and for what the result is used.
- It is written in the form of essay, not in numerical data.

References
- It must be written completely, based on the references.
- It only contains of the referenced sources in the content.
- The main references are min. 80% in the form of books publiced less than 10 years before the article. The references are, min. 80%, in the form of research articles in journals or research reports.
- The article must be referenced to the article included in "Jurnal Pendidikan Fisika Indonesia"
- The typing of bibliography must be accordiing to APA (American Psychological Association) Style.

Examples:
Articles in Periodicals
Articles in Journal Paginated by Volume

Harlow, H. F. (1999). Fundamentals for preparing psychology journal articles. *Journal of Comparative and Physiological Psychology*, 55, 893-896.

Articles in Journal Paginated by Issues

Kansiati, C. L. (2006). Orientasi baru penyelenggaraan pendidikan program profesional dalam memenuhi kebutuhan dunia industri. *Jurnal Pendidikan Fisika Indonesia*, 8(1), 57-65.

Articles in a Magazine

Henry, W. A., III. (2005, April 12). Making the grade in today's schools. *Time*, 135, 28-31

Articles in a Newspaper

Pitunov, B. (2008, Desember 13). Sekolah unggulan ataukah sekolah pengunggulan?. *Majapahit Pos*, pp. 4, 11.

Books
Edited Book with an Author or Authors

Morshed, M. M., & Haseeb, A. S. M. A. (2009). *Physical and chemical characteristics of commercially available brake shoe lining materials : A comparative study*. Dhaka : Materials and Metallurgical Department, Bangladesh University of Engineering and Technology.

A Translation

Ary, D., Yacobs, L. C., & Razavieh, A. (2001). *Pengantar Penelitian Pendidikan*. (A. Furchan, Trans). Surabaya : Usaha Nasional. (Original Work published 1976)

Edition Other Than First

Helfer, M. E., Kempe, R. S., & Krugman, R. D. (2000). The battered child (5th ed.). Chicago, IL: University of Chicago Press.

Article or Chapter in an Edited Book

O'Neil, J. M.,& Egan, J. (1999). Men's and women's gender role journeys: A metaphor for healing, transition, and transformation. In B. R. Wainrib (Ed.), *Gender issues across the life cycle* (pp. 107-123). New York, NY: Springer.

Electronic Sources (Web Publications)
Article From an Online Periodical with DOI

Assigned

Wooldridge, M. S., & Shapka, J. (2012). Playing with technology: electronic toys. *Journal of Applied Developmental Psychology*, 33(5), 211-218. http://dx.doi.org/10.1016/j.appdev.2012.05.005. Or doi: 000000000/000000000

Article From an Online Periodical with no DOI Assigned

Kenneth, I. A. (2000). A Buddist response to the nature of human rights. *Journal of Buddist Ethics*, 8. Retrieved from http://www.cac.psu.edu/jbe/twocont.html

Newspaper Article

Parker, T. (2008, May 6). Psychiatry handbook linked to drug industry. *The New York Time*. Retrieved from http://well.blogs.nytimes.com

Electronic Books

De Huff, E.W. (n.d.). *Taytay's tales: Traditional Pueblo Indian tales*. Retrieved from http://digital.library.upenn.edu/women/dehuff/taytay/taytay.html

Davis, J. (n.d.). *Familiar birdsongs of the Northwest*. Available from http://www.powellls.com/cgi-bin/biblio?In-key=1-9780931686108-0

Other Print Sources
Dissertation/Thesis, Published

Wahyuni, S. Y. (2009). *Pengembangan uji kompetensi mandiri berbasis komputer untuk meningkatkan efikasi diri siswa* (Doctoral dissertatation). Retrieved from name of database

Dissertation/Thesis, Unpublished

Kuntoro, T. H. (2007). *Pengembangan kurikulum pelatihan magang di SMK : Suatu studi berdasarkan dunia usaha* (Unpublished Doctoral dissertation). Program Pasca Sarjana UNNES, Semarang.

Government Document

National Institute of Mental Health. (2008). *Clinical training in serious mental illness* (DHHS Pubication No. ADM 90-1679). Washington, DC : U. S. Government Printing Office.

Conference Proceedings

Suci, P., Tjipto, P., & Budi, J. (Eds.). (2013). Implementasi penggunaan simulasi phET dan KIT sederhana untuk mengajarkan keterampilan psikomotor siswa. , *Prosiding Seminar Nasional IPA IV* . Semarang: Program Studi Pendidikan IPA S1 FMIPA UNNES.

ACKNOWLEDGMENTS TO THE REVIEWERS

Best regards,
Editor-in-Chief

Sutikno

FORMULIR BERLANGGANAN
JURNAL PENDIDIKAN FISIKA INDONESIA (JPFI)

Mohon dicatat sebagai pelanggan Jurnal Pendidikan Fisika Indonesia

Nama	:	
Alamat	:	
No. Telp	:	
Email	:	

Berlangganan mulai Nomor ...... Tahun ....Selama......Tahun

Harga Langganan ☐ 1 Tahun = Rp 120.000,- ☐ 2 Tahun = Rp 200.000,-	Harga per exemplar Rp 60.000,- + ongkos kirim Rp 25.000,- (P. Jawa) & Rp. 30.000,- (Luar P. Jawa)
Biaya berlangganan saya kirim lewat rekening a/n Pratiwi Dwijananti BNI KC Semarang No. Rek.: 0506841280	........................,........................... (....................................)

*Formulir berlangganan dan bukti pembayaran harap dikirim ke alamat redaksi atau melalui fax / email redaksi JPFI