



STUDYING NATURAL SCIENCE IN ELEMENTARY SCHOOL USING NOS-ORIENTED COOPERATIVE LEARNING MODEL WITH THE NHT TYPE

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ABSTRACT

Elementary school students' achievement in natural science in the academic year of 2015/2016 at Cluster V, Buleleng regency, Bali province was considerably low. An early observation also revealed low motivation, negative attitudes towards teachers, low self-esteem and low confidence in self-capability. Therefore, a breakthrough approach was urgently required to improve the students' performance in natural science learning. The current article aimed at investigating the effects of the (Nature of Science) NOS-oriented cooperative learning model with the Numbered Head Together (NHT) on the elementary school students' achievement in natural science. The study was a quasi-experimental research adopting the post-test only control group design. The research conducted in elementary schools in Cluster V Buleleng sub-district, Buleleng regency, Bali, Indonesia. The research subject was 137 students in Grade 5 consisting of six classes from 5 elementary schools. The hypothesis was examined using an inferential statistics, the t-test. The results showed that there was a significant difference in the learning results of natural science between the students taught with the NOS-oriented cooperative learning model with the NHT type and those with the conventional learning model ($t_{count} = 7,048 > t_{table} = 2,000$). The students taught with the NOS-oriented constructive learning model with the NHT type achieved better than those with the conventional learning model. Therefore, it concluded that the NOS-oriented cooperative learning model with the NHT type gave positive effects on the fifth year students' achievement in natural science learning.

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Keywords: cooperative learning, elementary student, NHT

INTRODUCTION

The learning process implements in an interactive, inspirational, pleasing, challenging, and motivating style that facilitates students to take parts in the process actively and to give enough opportunities for the students' initiative, creativity, and autonomy in line with their talents, interests and their physical and psychological development. This activity systemically conducted

through the process of exploration, elaboration, and confirmation. This regulation is in line with the constructivism in which an individual is viewed to construct knowledge sustainably in assimilating and accommodating new information (Slavin, 1994). The basis of constructivism theory is that teachers' participation does not merely provide students with knowledge but also plays roles in developing students' ability, so that the students may be able to construct their own knowledge. Learning is not a stimulus-response paradigm but a process that needs one's self-di-

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rection and the formation of knowledge structure through reflection and abstraction.

The observation results conducted in 2015 in elementary school Cluster V Buleleng sub-district showed that the learning activities in natural science were lack of innovations. Firstly, the learning activities were teacher-centered resulting in passive students. The teachers merely transferred knowledge to the students, and they received it without any direct discovery. Such classroom activities encouraged students to only memorize information. Secondly, teachers tended to use lecturing methods serving in the students' verbal knowledge of natural science. Thirdly, the classroom learning activities emphasized the drills and the problem-solving skill stick only on the examples of problem-solving given by the teachers. This causes the students not to be able to discover the ways to solve problems independently. Fourth, the facilities and infrastructures supporting the learning activities such as props were not made use of maximally. Fifth, during the learning process, the teachers rarely presented concrete phenomena or media related to the studied materials. The students needed some concrete media but most materials and contents of presentation were book-oriented. This made the students unable to understand the materials well. Sixth, the learning activities oriented more to competitive learning style. Hence, this learning style could cause anxieties to the students and this condition may spoil their motivation and create a hostile situation in the classroom.

The above findings supported by Lie (2002) suggesting that high achievers are often hated by their classmates since they are considered to increase the average grades and to bring their classmates down. Whereas, low achievers may cause some antipathy to classmates, teachers, school or even to the learning process. The label as losers in this competition may become a stigma or an inner wound that may always bother them in their lives. Widiana & Jampel (2016) state that there are many elementary school teachers in Bali whose learning processes are monotonous like those described above and this causes their students' achievement to be low at the end. This learning process also applied for all subjects in elementary schools since the elementary school education in Indonesia adopts the home-room teacher system namely one teacher should handle 1 class in the learning process on the whole day for one year.

The teachers in elementary school cluster V, Buleleng sub-district have an opinion that the learning package is seen from the basis of maste-

ry learning without paying any attention to the learning process. It is in contradiction with the constructivism suggesting that students at all levels of ages actively involved in the process of gaining information and construct their own knowledge. As a result, the students' achievements are low. Based on the results of observations and document recording of grade 4 at the even semester in the academic year of 2015/2016, in which the concerned students were still in Grade 5 in the odd semester in the academic year of 2016/2017, found that the learning achievement of 5 Grade students in Cluster V Buleleng sub-district was under low category. It shows their average scores of the semester exam for natural science which was under the Minimal Mastery Criteria of 65 (see Table 1). Natural science subject is one of the subjects in elementary schools studying a theoretical science based on the observations and experiments of the natural symptoms (Rahmawati, 2014).

Table 1. The Average Scores of the Semester Exam II for Natural Science of Students in Grade IV, Cluster V, Buleleng, Academic Year of 2015/2016.

School Name	Average Score	Score of Minimal Mastery Criteria
ES No.1 Petandakan	60	75
ES No.2 Petandakan	58	75
ES No.1 Sari Mekar	61	75
ES No.2 Sari Mekar	62	75
ES No. 1 Nagasepaha	60	75

The results of interviews with teachers and students revealed that the low quality of students' achievement in natural science was caused by some personality factors that did not support the learning activities such as low motivation, negative attitudes towards teachers, low self-esteem and low confidence in self-capability. Moreover, problems appearing during the learning process also caused students not to be enthusiastic and this was getting worse by the fact that most students did not concentrate on their learning process. It is in line with the results of observations that during the teaching and learning process in the natural science subject, the ways teachers presented the materials of natural science were less interesting. In the teaching-learning process, the teachers seemed to play active roles in presenting materials dealing with the concepts studied by students. The students tended to be passive and

do less thinking processes. It is parallel with the research by Tirtasari, et al. (2015) suggesting that students' low achievement was caused by teachers' less innovative ways in packaging the learning process as clearly seen from the students' achievement in natural science.

On the basis of the condition, it is necessary to make some innovations in the natural science learning process in elementary school. The learning process of natural science should be based on the constructivist paradigm, a view on the learning activities that help students internalize, reform, or transform new information. In constructivist learning, it is the students who should be responsible for what they are learning, for becoming autonomous thinkers, developing integrated concepts, asking challenging questions, and for discovering their answers independently (Windschitl et al., 2008; Cobern, 2012). Some research also has revealed that constructivist-based learning may improve the students' learning process and achievement (Zaenuri et al., 2017).

To solve the weaknesses of such competitive and teacher-centered learnings as found in Cluster V Buleleng sub-district, Slavin (1994) suggests a learning setting with collaborative aspect namely cooperative learning model. It is parallel with the characteristic of the learning of natural science at school: the learning aims to help students study the main concepts and principles and apply them to solve any problems through various experiments/practices (Logman et al., 2012; Liu et al., 2009). The cooperative learning model is practical techniques that may be applied by teachers in their classrooms every day to help students study each subject, from basic skills to solve complex problems (Agustin et al. (2013). In the cooperative learning method, students work together in groups of 4-6 to attain the understanding of the materials the teacher gave. Therefore, this cooperative learning model requires students to learn in mutual cooperation to solve problems, since this would promote interactions among students and help them foster a social relationship with their partners (Efriza & Mukhaiyar, 2013).

According to Slavin (1994), the strength of the cooperative learning takes place in the opportunities obtained by students to discuss a problem, determine the strategies in solving it, and relate the problem with others that have already been solved. Learning in a cooperative group may train students to listen to others' ideas and to summarize the ideas or findings in the form of writing. Moreover, cooperative learning may also help students improve their positive attitudes towards natural science subject. Therefore, this

may reduce or even omit any anxieties about the natural science subject that has much been experienced by students.

One of the effective cooperative learning models to improve the quality and achievement of natural science due to some problems above is the Numbered Head Together (NHT) type. NHT is a type of the cooperative learning models developed by (Kagan, 1994) to involve more students in studying the materials covered in a subject and to check their comprehension of the contents (Kusumaningtyas & Kusmayadi (2014). Moreover, NHT is a cooperative learning type designed to influence the pattern of the students' interactions as an alternative for a traditional class structure. It is a structured working system/study group in which positive interdependence, individual responsibility, personal interactions, expertise in cooperation and group process occur when students spend most of their time in the classroom in groups of 4-5 and accept recognition and rewards based on their groups' academic performances.

Novita (2008) explained the general steps in the model, which are (1) Numbering. Teachers divide students into some groups or teams consisting of 3-5 and give them numbers so that each student in the group has a different number. (2) Questioning. Teachers ask a question to students. The question may be various, from specific to general. (3) Head Together. Students think together to describe and to assure that each student knows the answer. (4) Answering. Teachers mention one number and students in each group with the same number raise his/her hand and are ready to answer for the whole class.

By studying the steps of NHT model in Cluster V Buleleng sub-district, it can be synthesized that the learning activities in the region were student-centered. Some findings underlying this was; first, the teachers did not use the lecturing method; second, the students were actively involved in the learning process; third, the students were asked to actively involved in discovering their own knowledge; fourth, the learning process made use of learning media either hand-made or those provided in the lab to make the learning process more interesting, and fifth, the learning became more collaborative in nature so that scientific sharing would happen during the learning process. Therefore, the elementary students' low achievement in natural science in Cluster V Buleleng sub-district may be improved.

This is reinforced by Zaenuri et al. (2017) stating that there are some improvements in the students' achievement in natural science when

the cooperative learning model of NHT applied to the students Grade IV, semester I of the elementary school in Selat, Sukasada sub-district, Buleleng regency in the academic year of 201/2016. The average score of the achievement in the Cycle I was 66.75% which was under the 'moderate' category. Then, in the Cycle II, the average scores increased to 88.25% which was under the 'high' category in terms of the achievement level. Sastrawan, et al. (2014) also found out that there is a positive effect of the NHT type aided with learning media software on the achievement in natural science among the students in Grade 5 in Cluster III Busungbiu sub-district. The average score of the students' achievement in natural science taught using the cooperative learning model with the NHT type aided with learning media software was higher than those taught using conventional learning model.

It is believed that basic inquiries should be applied to teach natural science in elementary school instead of concept memorization. Therefore, in this research, the NHT type is oriented into the concepts of NOS. NOS-oriented learning is defined as "the nature of knowledge", which is a complex concept involving the philosophy, sociology, and history of a knowledge. The advantages of inserting the NOS to the standard/curriculum are improving the achievement of science materials, promoting the interest in science, and developing the decision making to any problems dealing with science (Widowati, et al, 2017). Santyasa (2007) suggested that NOS covers three things: ontology, epistemology, and axiology which are the bridge for the students in revealing and understanding the reality of nature that is really needed by students to understand their own identity and raise their awareness to love the nature and its contents. NOS-oriented learning has six parts namely (1) *background readings*, (2) *case study discussions*, (3) *inquiry lessons*, (4) *inquiry labs*, (5) *historical studies*, (6) *multiple assessments*.

There are five arguments about the importance of understanding NOS: (1) utilitarian; understanding NOS is needed to recognize science and to manage technological objects and process in daily life; 2) democratic; understanding NOS is required to get any information used to make decisions on socio-scientific issues, 3) cultural; NOS ought to be understood to respect the values of science as part of contemporary cultures, 4) moral; NOS is understood to help develop some understanding about the norms in scientific community in realizing some moral commitment to general values in the society, 5) science learning; understanding NOS may facilitate the learn-

ing of materials in the science subject (Khishfe, 2012).

The concept of NOS learning-oriented has some characteristics related to nature so that students may be able to understand the learning materials contextually. The characteristics of NOS, which are: (1) NOS is good to be explicitly taught to future teachers and students to dig out concepts of natural science; (2) NOS are good to be contextually taught. Students may develop their functional understanding about NOS when they are taught in the context of scientific inquiry so that the learning is student-centered; (3) NOS is good to be taught on the basis of experiences. Teaching natural science through inquiry helps students understand the nature of scientific efforts seriously, where it cannot be obtained with full meaning through other ways; 4) NOS is good to be regularly taught. Regular treatment of the NOS subject matter covers a wide situation that will inspire students with understanding as it is; (5) NOS is good to be systematically taught. Teachers should know what to teacher dealing with the topics and mention all arrangements of information about NOS to the students. Teaching any subjects carelessly will result in some gaps in students' achievement. (6) By merely helping teachers focus their attention on NOS as an important purpose in the learning process, they will be able to produce the learning of natural science more clearly (Donche & Petegem, 2011).

From the research results about NOS, it is suggested that teaching aspects of NOS be explicitly made with either contexts or non-context, as clearly stated in the curriculum/standard, textbooks or in the learning process in the classroom. It was found that the application of the visual media-aided NOS Learning Model was able to the achievement of Students Grade 5, Semester I in the academic year of 2011/2012 in Elementary School No. 2 Rendang, Rendang sub-district, Karangasem regency. It may be seen from their average score of 57.5 in the Cycle I and it became 70.93 in the Cycle II. Moreover, Haydon, et al. (2010) found that there is a positive effect from the NOS-oriented learning model on the students' understanding of the concepts of natural science. The theory used as the base for this research is the constructivism view that gives an emphasis on the student-centered learning activity so that the students may be able to construct their knowledge based on their own experiences.

This research tried to test the effects of the NOS-oriented cooperative learning model with the NHT type on the elementary school students' achievement in natural science. Teach-

ers are expected to make the research results as one of the references to make their activities in learning natural science in elementary school more interesting, challenging, motivating and pleasing. Moreover, the research results would be able to support the students' achievement based on the expected basic competence possessed by the students of Grade 5 in elementary school. It is also expected that these research results would contribute to the development of the learning process in the field of natural science that has been achieved dealing with the application of the NOS-oriented cooperative learning model with the NHT type in elementary school.

METHODS

This article is written based on the results of quasi-experimental research adopting the post-test only control group design. The research was conducted in elementary schools in Cluster V Buleleng sub-district, Buleleng regency in the semester I in the academic year of 2015/2016. The population was 137 students Grade V consisting of 6 classes from 5 elementary schools namely ES No. 1, 2 Petandakan, ES No. 1, 2 Sari Mekar, and ES No. 1 Nagasepaha in Cluster V Buleleng sub-district, Buleleng regency in the academic year of 2015/2016. Fifty-nine students divided into two classes were randomly taken.

The data were students' achievement in the natural science subject. The data were collected through multiple choice test type with 20 items that had been contently and empirically validated. In terms of the content validity, the test employed had met the elements of the basic competence with good sentences in line with the psychological development of the students Grade 5 of elementary school. The empirical validity, however, was analyzed from the internal consistency of the 20 test items, and all the test items after being tested are valid. From the analysis of the discriminating power of test items, 3 test items qualified as very good; 9 items as good, and 8 items as moderate. From the analysis of the test difficulty level, 13 test items are under the easy, 5 items under moderate, and 2 under difficult. The analysis of the test reliability found that the test was qualified as high (0.66). The data on students' achievement in natural science were collected from

the students using the post-test design after the NOS-oriented cooperative learning model with the NHT type and the conventional learning method had been applied.

The research hypotheses were analyzed using the t-test. However, to give some descriptions of the distribution of the research data, a descriptive analysis was made using the ideal mean criteria and the ideal standard deviation as presented in Table 2.

Table 2. The Ideal Mean Criteria and Standard Deviation

Score Range	Real Score Range	Category
$Mi + 1,5 SDi \leq X \leq Mi + 3,0 SDi$	$14,95 \leq X \leq 20$	Very high
$Mi + 0,5 SDi \leq X < Mi + 1,5 SDi$	$11,65 \leq X < 14,95$	High
$Mi - 0,5 SDi \leq X < Mi + 0,5 SDi$	$8,35 \leq X < 11,65$	Moderate
$Mi - 1,5 SDi \leq X < Mi - 0,5 SDi$	$5,05 \leq X < 8,35$	Low
$Mi - 3,0 SDi \leq X < Mi - 1,5 SDi$	$0,01 \leq X < 5,05$	Very low

(Koyan, 2012)

RESULTS AND DISCUSSION

This research found that the experimental group after being treated with the NOS-oriented cooperative learning model with the NHT type, 58.62% students got the scores under the high and very high categories, 37.93% students were under the moderate category, 6.90% under the 'low' and 'very low' categories. However, the control group showed different scores, and after being treated with the conventional learning method, 55.17% students got scores under 'low' and 'very low' categories, and 44.83% students were under the moderate category, but 0.00% students got the scores under 'high' and 'very high' categories. Therefore, it is descriptively stated that the distribution of the data in this research shows that the data on the students' achievement in the experimental group tended to be under the moderate or higher category, while in the control group, it tended to be under the moderate or lower category. The detailed post-test results of 30 students in the experimental group and 29 students in the control group are presented in Table 3.

Table 3. Post-test Results of the Students from the Experimental and Control Groups

Real Score Range	Experimental Group	Control Group	Category
$14,95 \leq X \leq 20$	3 (10,34%)	0 (0,00%)	Very high
$11,65 \leq X < 14,95$	14 (48,28%)	0 (0,00%)	High
$8,35 \leq X < 11,65$	11 (37,93%)	13 (44,83%)	Moderate
$5,05 \leq X < 8,35$	2 (6,90%)	12 (41,38%)	Low
$0,01 \leq X < 5,05$	0 (0,00%)	4 (13,75%)	Very low

Based on five-scale criteria and in line with the results of the data analysis, it knows that the mean score of the students' achievement in natural science in the experimental group, namely the group treated using the NOS-oriented cooperative learning model of NHT was 11.7 (under the high category). Whereas, the mean score of the students' achievement in natural science treated with the conventional learning model was 8.07 (under the moderate category). It means that the mean score of the students' achievement in natural science in the experimental group was higher than that in the control group. The data on the mean and standard deviation of post-test results of two groups are presented in Table 4.

Table 4. The Mean and Standard Deviation of the Post-Test Results of the Experimental and Control Groups

Variable	Experimental Group		Control Group	
	Mean	Standard Deviation	Mean	Standard Deviation
Post-test	11,7	2,01	8,07	1,98

Before testing the hypothesis with the independent t-test, testing the prerequisite was needed for the distribution of the research data was made. The test of analysis of prerequisite includes two aspects: (1) the normality test of the data distribution for the whole analysis units, and (2) the homogeneity test of the variance among groups.

The normality test of the data made to the whole analysis units namely the experimental and the control groups using the Kolmogorov-

Smirnov and Shapiro-Wilk analyses. The process of the analyses was supported by the program of the SPSS 16 for Windows. The data normality was determined by the significance of the results of the analysis. The data are said to be normally distributed if the number of the significance obtained is more than 0.05 of at the significance level of 5%. The summary of the results of the normality test of the data in the experimental and the control groups are presented in Table 5.

Table 5. Summary of the Results of the Normality Test of the Data Distribution

Learning Model	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Experimental Group	0,119	30	0,200	0,957	30	0,254
Control Group	0,129	29	0,200	0,929	29	0,052

Based on Table 5, it explains that the significance level is higher than 0.05 for all the units of analyses conducted using either the Kolmogorov-Smirnov or Shapiro-Wilk. This shows that the data in the experimental group distributed normally. This also happens with the control group. Therefore, the significance levels for whole units of analysis using either the Kolmogorov-Smirnov or the Shapiro-Wilk are higher than 0.05, showing that the data in the control group also normally distributed.

The homogeneity test of the variance made for the data of the achievement of natural science in the experimental and control groups. The number of each unit of analysis was 30 and 29 students, respectively. In testing homogeneity of the variance between the groups, the F-test was employed. The data said to be homogeneous if the $F_{count} < F_{table}$. The summary of the results of the homogeneity test of the variance is presented in Table 6.

Table 6. Summary of the Results of the Homogeneity Test of the Variance using the F-test

Sample	Mean	SD	Variants	F_{count}	F_{table}	Conclusion
Experimental group	11,7	2,01	4,04			
Control group	8,07	1,98	3,92	1,03	1,85	$F_{count} < F_{table}$

Based on Table 6, with the aid of the program of *Microsoft Excel 2007 for Windows* it is shown that $F_{\text{count}} < F_{\text{table}}$, meaning that the variance between the groups of the students is homogenous.

The hypotheses tested in this research states that there were differences in the result in studying natural science between students taught using the NOS-oriented cooperative learning method of NHT type and those taught using the conventional learning model. To test the proposed hypothesis, the independent-t-test or uncorrelated t-test was employed. Table 6 shows that when the variance is homogenous and the number of the student in each the class is the same, in the uncorrelated t-test, the pooled variance is adopted. The summary of the results of the uncorrelated t-test is presented in Table 7.

Table 7. Summary of the Data of the Results of the Hypothesis Testing

Group	Variance	N	db	T _{count}	T _{table}	Conclusion
Experimental group	4,04	30				T _{count} > t _{table} Ha is accepted
Control group	3,92	29	57	7,048	2,000	

According to the hypothesis proposed in the theoretical study of the hypothesis testing criteria, H₀ is unaccepted if the $t_{\text{count}} > t_{\text{table}}$ and H₁ is accepted with the significance level of 5%. In this research, the condition was supported by the difference in the mean score obtained by the experimental group, namely 11.7, under the very high category, and the control group, namely 9.07 under the 'moderate' (very high) category, the alternative hypothesis is accepted. It is also shown by the summary of the data of the hypothesis testing results that the $t_{\text{count}} > t_{\text{table}}$, therefore H₀ is unaccepted and H₁ is accepted. Therefore, it is interpreted that there was a significant difference in the achievement between the group of students taught using the NOS-oriented cooperative learning model with the NHT type in the natural science subject and those taught using the conventional learning model in the students grade V, in the odd semester in the academic year of 2012/2013 in elementary schools in Cluster V, Buleleng sub-district, Buleleng regency.

This research result shows that there is a difference in the result of studying the natural science subject between the group of students

taught using the NOS-oriented cooperative learning model and that of those taught using the conventional learning model. The mean score of the achievement in the natural science subject taught using the NOS-oriented cooperative learning model with the NHT type is 11.7 which is higher than the mean score of those taught using the conventional learning model, namely 8.07. It means that the NOS-oriented cooperative learning model with the NHT type positively gave effects on the 5 graders' achievement on the natural science, in the odd semester, academic year of 2012/2013 in elementary schools in Cluster V, Buleleng sub-district, Buleleng regency.

This research result showed that in the group of students taught using the NOS-oriented cooperative learning model with the NHT type, 58.6% students got scores under the high and very high categories, 37.93% students under the moderate category, and 6.90% student under the low and very low categories. This variation shows that the students' achievement is not only influenced by some factors of the learning model presented by the teacher, but also by some assumed factors of the facilities and infrastructures, students' self-confidence, learning motivation, students' talents, students' economic condition, school climate and management as suggested by the results of interviews with the students. This result reinforces a theory stating that the factors influencing the students' achievement may be categorized into two types namely internal factors coming from the students themselves and the external ones, from out of the students.

This research result is also supported by Sudirgayasa, et al. (2014) who found that there are ten factors influencing students' achievement in the accounting subject, namely: motivation, senses, the relation between the teacher and the students, the parents' attention, school discipline, the relation among the students, the relation among the family's members, learning tools, peer groups, and the parents' tolerance. Widiana & Jampel (2016) found that request and motivation also influence the students' achievement.

The application of the NOS-oriented cooperative learning model with the NHT type was in line with the characteristics of the elementary school students at the concrete operational stage. It may be seen from their enthusiasm to be able to see, do something, involve learning, and experience directly at anything studied. The students were really interested in any materials specially packaged by the teacher according to their daily lives, moreover, they were asked to play during the learning process. It is supported

by Piaget suggesting that elementary school students are at the concrete operational stage (from 7 to 11 years old) in which the concept existing at the early age is an opaque concept, and then at present, it becomes more concrete. Elementary school students make use of the mental operation to solve actual problems. They are able to use their mental capability to solve concrete problems also state that at the concrete operational stage, students are able to show concrete operations, logical thinking, object classification and thinking about the relationships among types of objects. Students' life experiences contribute to sharpening concepts. At this stage, elementary school students are able to think, learn, remember, and communicate since their cognitive process is not egocentric but logic.

This research result still reinforces the constructivism theory to improve the students' achievement. The learning process of the students taught using the NOS-oriented cooperative learning model with the NHT type is more attractive, pleasing and motivating for the students to learn. The results of the interviews with some students showed that the students felt to have more chances to explore themselves in the learning process. These students' statement supports the von Glasersfeld's (1989) learning concept that learning is not a stimulus-response symptom but a process that needs self-direction and one's structural construction of knowledge through reflection and abstraction. Learning is a process of efforts one makes to get new behavioral changes as a whole as the results of their own experiences with their environment. It is in line with the characteristic of the NHT learning that students are more involved in studying materials covered in a subject and checking their comprehension of the content of the lesson.

Moreover, the students also felt that they become more productive and careful in learning natural science. They seemed to be enthusiastic during the learning process either at the practices or at the group discussion. The students became more responsible for the problems given to them, more active in answering questions, and made the process of sharing knowledge among members of the group and among the members from other groups into reality. NHT learning model indirectly trains the students to share information, listen to and speak carefully to others, so that they are productive in the learning process (Kagan, 1994).

This research result also confirms some research results made by among other that the

cooperative learning model with the NHT type gave effects on the students' achievement in the natural science (Sastrawan et al., 2014). Another research result also shows that the cooperative learning model with the NHT types applied in the learning activities significantly influenced the attainment of the students' achievement as a whole (Haydon et al., 2010). Besides strengthening the research of the application of the cooperative learning model with the NHT type, this research result also supports the research results of the application of the NOS-based learning model. The NOS-based learning model may improve the learning quality and also the resulting achievement in the learning activities. The application of the NOS-based learning process give significant effects on the students' achievement (Sudirgayasa, et al., 2014).

CONCLUSION

This research discovers that the NOS-oriented cooperative learning model with the NHT type gave positive effects on the achievement in the natural science of the students Grade V in the odd semester, academic year of 2015/2016 in elementary schools in Cluster V Buleleng sub-district, Buleleng Regency. The NOS-oriented cooperative learning model showed better results in the students' achievement than the conventional learning model in natural science. This research positively contributes to the development of science, especially in the learning of the natural science. Therefore, it is suggested that teachers teach the materials of natural science using the NOS-oriented cooperative learning model as one of the alternatives to learning natural science so that the learning process becomes more effective. This research may also be made as a reference for further researches with different materials or subject matters, different grades, and those with new variables as a new creativity.

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CHEMOENTREPRENEURSHIP WITH COOPERATIVE INTEGRATED PROCESS INQUIRY STRATEGY TO INCREASE ENTREPRENEURIAL INTEREST AND LEARNING MOTIVATION

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ABSTRACT

Colloid chemistry learning at SMAN 1 Mijen Demak had a less useful impact as it has not integrated the process of making with the products needed in everyday life. The lesson also did not equip students with the skills in entering the entrepreneurship world. The observation results indicated that the XI IPA1 grade students in SMAN 1 Mijen Demak had low entrepreneurial interest and motivation. This was due to the tedious and less-motivated chemistry learning. Therefore, this study aimed to increase the students' entrepreneurial interest and learning motivation on colloid materials through Integrated Cooperative Inquiry Process strategy. A classroom action research applied in this research consisted of three cycles. Each cycle had several stages which were planning, implementation, observation, and reflection. The data on the students' entrepreneurial interest and learning motivation were collected through observation and questionnaire. The descriptive analysis was adopted in this research. The data were analysed using the average mastery and proportion. Based on the analysis of cycles I, II and III, the percentage of the students' entrepreneurship interest increased from 47.64% to 51.17%; 72,16% and 81,10% having 38 students achieved the mastery learning. While the learning motivation increased from 49.55% to 56.08%; 68.21% and 76.32% having 37 students reached the mastery learning. It concluded that the CIPI (Cooperative Integrated Process Inquiry) with CEP (Chemo entrepreneurship) approach could increase the students' entrepreneurial interest and learning motivation.

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Keywords: Chemoentrepreneurship, CIPI, interest, motivation

INTRODUCTION

The colloid is a heterogeneous mixture of two or more substances in which each particle substance measures between 1 and 1000 nm and are dispersed (distributed) evenly in the medium of another substance (Bergstrom, 2017). Colloidal systems are commonly found in everyday life, such as in nature (land, water, and air), industry, medicine, living systems, and agriculture. In the industry itself, the application of colloids

for production is wide enough. This is due to the important characteristic properties of colloids, which can be used to mix substances that cannot be mutually homogeneous and stable to each other for large-scale production. In this study, we applied to learn the chemistry of colloid material with the chemoentrepreneur approach. The selection of colloid materials intended to train students in making industrial products. Students chose industrial products such as soap and water purification.

Heretofore, the learning process has not given any access to students to independently

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develop through innovating and thinking process (Arinda, 2014). SMA Negeri 1 Mijen Demak already has adequate learning facilities such as Science laboratory, ICT, and library but it was not optimally utilized. Based on observations and interviews with the chemistry teachers, 30% of the students did not join chemistry lessons, especially in the last-school hour. Though the teachers have given learning models, there were some students who did not pay attention. This was due to the students' lack of learning motivation. The teachers have not assigned the practicum courses to the students to make products, while chemistry is very close to human needs products and this, at the same time, could cultivate the students' entrepreneurial spirit. Therefore, the researchers observed the students' entrepreneurial interest and learning motivation using questionnaires. The obtained initial results of the entrepreneurial interest and learning motivation were 47.64% and 49.55% respectively. The low motivation to learn would affect the students' learning outcomes and learning objectives, which are not expectedly achieved. Suprihatin (2015) stated that teachers are very interested in improving motivation to learn through the use of varied learning methods and provide learning experiences. The statement is supported by research results from Tukiran (2017) that chemical-based learning would improve students' life skill. To overcome this problem, a research on the CEP (Chemoentrepreneurship) approach in combination with CIPI (Cooperative Integrated Process Inquiry) strategy has been established to increase the students' entrepreneurial interest and learning motivation (Supartono, 2009; Wijayanti et al., 2015).

The CEP orientates to express the skills of students. Therefore, it is possible to learn the techniques of a material processing into a useful product that have economic value as also embracing the entrepreneurial spirit. The CIPI strategy is to develop the CI (Cooperative Inquiry) learning model which aims to improve professionalism and builds meaningful relationships among individuals in groups, emphasizing practice and action. The steps included research focus list, agreeing the research focus through discussion, problem analysis, designing and prioritizing solutions to a problem, defining the implementation process and outcomes for solutions, enacting solutions, reflecting effectiveness and repeating processes if necessary (Mardis, 2013). Saputra (2016) showed the result that an effective inquiry study improved critical thinking skills and the mastery of the concept of colloid material. Susanti (2016) conducted a stu-

dy indicating that inquiry model learning could improve the science process skill in junior high school students.

The CEP approach intends to increase students' entrepreneurial interest from 5 indicators, which are the feeling of pleasure or interest to a product, participating in making products, awareness of the efforts conducted, willingness to deepen science and paying attention to a target object. These are the development of the students' learning interest indicators of pleasure, participation, awareness, willingness, and attention to an object (Aritonang, 2008; Rosmiati et al., 2015). On the other side, the CIPI strategy aims to improve students' learning motivation assessed from 5 indicators of learning persistence, tenacity in facing difficulties, interests and attention to learning, achievement, and learning independence (Agustina, 2011).

In addition, here are some prior research relating with this colloid inquiry-based chemo-entrepreneurship. Project and inquiry-based learning activities were appropriately efficient and effective, therefore, science teachers could implement both teaching methods in the organization of activities appropriate for learners (Panasan & Nuangchalerm, 2010; Abdi, 2014; Carnawi, 2017; Utomo et al., 2016). The chemo-entrepreneurship (CEP) learning approach is applicable in learning to develop students' cooperation and communication since it requires students to work together to achieve the mastery learning and good communication skill (Paristiowati et al., 2105; Sadraei et al., 2017). The use of CEP approach in combination with SETS (Science, Environment, Technology, and Society) could increase the students' learning result, also, boost motivation, and interest in learning chemistry (Rohmadi, 2011). The findings showed that it was possible to achieve higher science concept learning when the scientific inquiry process was integrated into a designed setting, motivated by each meeting needs that the students articulated themselves (Mehalik et al., 2008). Our study supported these claims: inquiry lab students demonstrated a small but significant gain in science literacy and science process skills compared to students enrolled in the traditional cookbook labs. However, Instructors following in our footsteps should be aware of the challenges. Also, our inquiry lab students had their experience rated lower on course evaluations but exhibited an interesting trend toward a more honest appraisal of their own abilities and an increased appreciation of their accomplishments (Gormally et al., 2009). We believe that they are some key findings of this meta-analysis.

First, our synthesis of a historical sample of studies from the years in which inquiry-based teaching is returning to prominence indicates a positive effect of this teaching approach on student learning, with a particularly large effect of students engaging in the epistemic domain of inquiry and the procedural, epistemic, and social domains combined. Second, the meta-analysis also indicates higher effect sizes for studies that involved teacher-led activities (Furtak et al., 2012; Lazonder et al., 2016; Qureshi et al., 2017).

METHODS

This was a Classroom Action Research consisting of three cycles having four stages each: planning, implementation, observation and reflection (Sumini, 2010). This research was conducted at SMA Negeri 1 Mijen Demak, with 39 students joined as the research sample. At the planning stage, the researchers constructed the colloid material learning device with the CEP approach and CIPI strategy. Furthermore, the design was implemented in the learning process. The next stage was to observe the interests of entrepreneurship. The reflection results on the first cycle were used as the basis for preparing the draft stage in cycle II to obtain the observation results from each cycle which was in the form of the students' entrepreneurial interest description. It was said successful if more than 30 students or above 75% of 39 students reached the good and/or excellent criteria.

RESULTS AND DISCUSSION

The results showed that there was an increase in learning motivation and entrepreneurial interest before and after the action. The cycles I, II, and III showed the improvement as presented in Table 1. This increase was due to the learning of colloid material applying the CEP approach with CIPI strategy. The CEP approach gave the students opportunities to practice making products having low economic value to products with a high economic value. The increased motivation affected the success of entrepreneurship. This is supported by research from Barba-Sánchez & Atienza-Sahuquillo (2017), revealing that business is not only influenced by ability and attitude but entrepreneurial motivation. Attitudes, motivations, and interests are needed for entrepreneurial students to be able to identify business opportunities to create new job opportunities (Rosmiyati, 2015). The CIPI's strategy provided the students time to choose, discuss, present, create and sell products, make reports, and write the motto of individual activities in the diary. The application of these strategies fostered the students to be actively and independently learning, solve problems, innovative, and acquire life skills. As the results of research conducted by Nur (2016), inquiry learning improved the students' characters and science skills. This study consisted of three cycles over three weeks. Each week included one cycle with six hours of lesson time. The observation sheet of the students' entrepreneurial interest and motivation in the cycle I, II and III assessed by the observers is presented in Table 1.

Table 1. The Observation Results in Cycle I, II and III

Observation sheets	Information	Cycle I	Cycle II	Cycle III
Entrepreneurial interest	Pleasure or interest (%)	50,77	69,77	82,62
	Participation (%)	62,30	83,01	81,41
	Awareness (%)	50,21	75,68	86,71
	Willingness (%)	45,71	63,08	77,82
	Attention to an object (%)	46,86	69,26	76,96
	Average score	51,17	72,16	81,10
	Students achieving the mastery learning threshold	5	34	38
Learning motivation	Learning persistence (%)	59,71	66,99	79,55
	Tenacity in dealing with problems (%)	47,76	68,59	80,77
	Interest and attention to learning (%)	57,05	69,23	74,36
	Learning achievement (%)	64,42	71,03	73,08
	Learning independency (%)	51,47	65,22	76,32
	Average score	56,08	68,21	76,32
	Students achieving the mastery learning threshold	8	25	37

In the first cycle of the first meeting, the students picked products from the Student Worksheet, discussed how to make products, presented and provided guidance. On the second meeting, the students made the products in the laboratory and sold it. On the third meeting, the students worked on questions, submitted reports, diaries, notebooks, repeated the materials learned and filled in the questionnaires. This indicated that the students were the center of activities during the learning process (Mandal, 2009). The entrepreneurial interest and learning motivation were assessed by five observers. The Cycle I has not fulfilled the 'successful' indicators based on the results presented in Table 1. The average scores of entrepreneurial interest and learning motivation in the Cycle I were 51.17% and 56.08% respectively. Inasmuch as the scores had not fulfilled the 75% of the completeness criteria, then reflection was done. Problems identified that the students have not been able to create product ideas, responsive, cooperative and confident while offering the product. They came late, considered products made as the schoolwork, had passive presentations, completed and submitted assignments late. Also, they were lack of reference sources, less paid attention to teachers, brought incomplete tools, practicum materials, and learning tools, lack of supervision, late in arranging reports and presentation, and had bad time-management to study chemistry.

In the second cycle, the learning process was carried out in the library. The activities were conducted in accordance with the reflection of cycle I that teacher re-explained the CEP approach with CIPI strategy, asked questions to students who did not pay attention, applied the jigsaw method (aiming to repeat the material)

to attract attention, provided direction about the learning equipment, data tools and materials for lab, community needs, and supervision schedules, elucidated the content and format of reports and presentation materials, gave direction for product offers, reminded the students to fill in the diaries and score reductions for those who did not complete the tasks on time. The learning cycle II has not met the 'successful' indicator as seen in Table 1. The cycle II got the average score for entrepreneurship interest and learning motivation of 72.16% and 65.22% respectively. Since it has not accomplished the 75% completeness criteria, then reflection was done. The identified problems were that the students were absent and/or late, lack of reference sources, supervision, report arrangement, time-management skill, responding skill to opinions, and delayed the task and submission.

In the Cycle III, the learning process was conducted in the ICT room having sufficient internet connection. On this cycle, the activities performed on the basis of cycle II reflection which was scheduling the supervision at least twice for each cycle, elucidating the content and format of the report, taking time to fill the diary, changing the lab, and creating a brochure to introduce the products. The learning process of cycle III has met the 'successful' indicator based on Table 1. The average scores of Cycle II on the students' entrepreneurial interest and learning motivation were respectively 81.10% and 76.32%. The indicators have fulfilled the mastery learning completeness of more than 75%, then the cycle was stopped.

The students' responses to learning were measured by questionnaires. The results are presented in Table 2 and Table 3.

Table 2. The Questionnaire Results of Entrepreneurial Interest in Cycle I, II, and III

Information	Cycle I	Cycle II	Cycle III
Students achieving the mastery learning threshold	39	24	39
Students not achieving the mastery learning threshold	0	15	0
Mastery learning percentage (%)	100	61,54	100
Pleasure or interest (%)	87,31	71,79	88,85
Participation (%)	85,58	69,55	88,78
Awareness (%)	91,48	73,26	91,85
Willingness (%)	81,55	61,67	83,46
Attention to an object(%)	85,98	67,71	87,50
Classical mastery (%)	86,30	68,80	88,09

Table 2 indicates that the students' response to the CEP learning with CIPI strategy, in terms of entrepreneurship interest, decreased by 15 students from the cycle I of 39 students to 24 students. While in the Cycle II to cycle III it enhanced by 15 students to 39 students.

Table 3. The Questionnaire Results of Learning Motivation in Cycle I, II, and III

Information	Cycle I	Cycle II	Cycle III
Students achieving the mastery learning threshold	36	22	37
Students not achieving the mastery learning threshold	3	17	2
Mastery learning percentage (%)	92,31	56,41	94,87
Learning persistence (%)	85,26	66,03	90,49
Tenacity in dealing with problems (%)	79,49	58,55	86,97
Interest and attention to learning (%)	64,90	64,74	71,96
Learning achievement (%)	84,62	66,54	90,90
Learning independency (%)	66,51	62,82	72,28
Classical mastery(%)	76,15	63,74	82,52

Table 3 reveals that the students' response to CEP learning with CIPI strategy on learning motivation decreased by 14 students from cycle I of 36 students to 22 students. While in the Cycle II to cycle III, it expanded by 15 students to 37 students.

The entrepreneurial interest was assessed from five indicators which expanded into 18 sub-indicators and summed up in statements on the observation sheet. (1) The indicator of pleasure and/or interest. For the sub-indicator of looking for reference sources, there were nine students in the Cycle I who completed searching the reference sources through observation and library research. After the teacher conducted reflection by inviting the students to study in the library, the number rose to 16 students. The reflection was done then by studying in the ICT room, which increased the number of the students to 24 students. For the sub-indicator of preparing tools and materials in the Cycle 1, there were 19 students brought tools and materials in accordance with the plan. This was a result of the reflection activity in which teacher invited the students to examine the workings of making the product so that the appropriate tools and materials were known. Therefore, all students completed the stage during the second and third cycles. The sub-indicator of supervision conducted in pre and while the product was made, there was one student having two times supervision completed the sub-indicators. This occurred after the teacher held the reflection activity in which teacher invited the students to have supervision. As a result, the number of students completing the sub-indicator rose to 21 students in the Cycle II and 36 students in the Cycle III. For the sub-indicator of human need problems, there were 10 students completed in the Cycle I having their products used to meet the

needs and earn money. A reflection was carried out to observe the products for its health impacts. In the Cycle II, the completed students increased by 29 students, and 37 students in the Cycle III. For the sub-indicators of creating product ideas, there were 10 students achieved the mastery learning by making an innovation to their own products. The reflection was carried out by re-explaining the CEP approach with CIPI strategy for observation and innovation on the products, resulting in 18 students completed the sub-indicators. Since it has not fulfilled the mastery learning threshold, the further reflection was undertaken by making posters, resulting in 28 completed students in the Cycle III.

Second, the indicator of participation. The sub-indicators included making notes about the products, of which there were 18 students in the Cycle I completed by recording materials and having a print out of the product. A reflection was taken by assigning students to find other sources than the Student Worksheet and record it since the sources provided was insufficient. The students reaching the sub-indicator in the Cycle II were 31 one and got down in the Cycle III to 22 students. This was due to the third cycle's assignment of only making posters. For the sub-indicator of references for making products, there were 21 students in the Cycle I who completed by carrying their reference books, notes, Student Worksheet, Chemistry books, and internet printout. Assigned were the students to find other sources, resulting in the rising completed students to 35 ones in the Cycle III.

Third, the indicator of awareness. The sub-indicator of business was performed when the product was less perfect. In the Cycle 1, there were 11 students completed by examining the products, asking the teacher, and discussing with

friends. A reflection was conducted by discussing products together with consumers and providing innovation (Susilogati, 2008). 34 students accomplished in the Cycle II, and 38 students in the Cycle III. For the sub-indicator of product planning accuracy, there were 21 students in the Cycle I completed by creating and innovating the products as presented. A reflection was carried out to make decisions, resulting in all students achieved the sub-indicator in the Cycle II and III. For the sub-indicator of accuracy in making the report, there was no student completed because no one achieved the score of 80-100. This was due to the students' inexperience in report making. The reflection on how to arrange a report was done. Finally, 19 students in the Cycle II and 35 students in the Cycle III had accomplished the sub-indicators.

Fourth, the indicator of willingness. For the sub-indicator of analyzing financial products, there were 17 students on the Cycle I completed by getting all the tools and materials purchased or rented, finding out the price in the market and calculating it whether or not they would make a profit. The reflection on re-explaining how to analyze costs was done. On the cycle II, there were 33 students and up to 37 students achieved on the next cycle. For the sub-indicator of supervision which was undertaken after the products were ready, 9 students completed the sub-indicator on the Cycle I by having supervision twice, at least. As a result, 25 students accomplished the sub-indicator on the Cycle II and 36 students on the cycle III. For the sub-indicator of students' willingness to explore the product, there was no student on the Cycle I achieved the threshold though they were given opportunities to choose products and innovate more on it. The reflection was done by directing the students to select the preferred products which were easy to make and sell. Therefore, 21 students completed the sub-indicator in the Cycle II. The reflection was needed to study the CEP approach in combination with CIPI strategy in depth, resulting in the number of completed students who rose to 29. For the sub-indicator of performance during the presentation, three students reached it in the Cycle I by asking, answering, resulting, daring to speak and express opinions. The reflection was performed by requiring each group to ask questions. In the Cycle II, there were 17 students completed and given a chance for the students to comment. In the Cycle III, the number fell to 16 students due to the limited time of presentation. Hence, the teacher gave a solution to write down the questions and answers submit it to the teacher to be

assessed.

Fifth, the indicator of attention to an object. For the sub-indicator of marketing, only eight students completed since their products were sold out. This low result was because of their lack of confidence. The reflection was done, deciding to sell the product collectively, and there were 18 students achieved it in the Cycle II. In as much as the products were less popular and attractive, a reflection on how to make it familiar was conducted by creating brochures. As a result, there were 26 achieved the mastery learning threshold of the sub-indicators.

The reflection was given to the students to be more spirited in promoting the products to consumers. For the sub-indicator of marketing tricks, 14 students completed by offering the products to their classmates, friends of different classes, teachers and sell it in the school canteen or cooperative. This happened since the students had no idea where to sell the products. In the Cycle II, 33 students completed and went up to 37 students in the Cycle III. The students created posters in the Cycle III and distributed it to wider area including the school's wall magazine. This is in line with the purpose of CIPI that is to engage students in a study that they find themselves and work in a team to document, describe and disseminate their insights from the experiences. For the sub-indicator of examining the tools and materials used for the lab, there were 10 students in the Cycle I who completed it by arranging the tools and materials on the table completely, neatly, and cleanly before the lab begins. This result was due to the less conducive learning so that they were busy with their respective jobs. As a result, they did not have time to prepare the tools and materials. The reflection was carried out by providing direction to prepare tools and materials and place it on the table so that the observers can directly assess. In the Cycle II, 34 students completed and were up to 35 students in the Cycle III. For the sub-Indicator of responding to opinions, there were 10 students accomplished the Cycle I, seen from their ethics in responding, for instance, by rising up a hand, standing, mentioning names and numbers, expressing opinions and thanking. A lot of students did not achieve the sub-indicator because of their lack of confidence. In addition, they used to ask before the teacher's invitation. The reflection was performed by directing the students to ameliorate their ethics. As a result, 12 students succeeded and the number went up to 15 students in the Cycle III. Nevertheless, the limited time allotment prevented them to convey their opinion since it took longer time

to boost their confidence. This is in accordance with research by Ospina (2008), that the activities can improve students' confidence in the learning process done in groups.

Learning motivation was assessed from five indicators expanded into 12 sub-indicators and summed up in statements on the observation sheet. First, The indicator of learning persistence. For the sub-indicator of attendance, 19 students succeeded by attending the chemistry class while the others did not. It happened since the chemistry was in the last-school hour and the teacher did not provide an interesting method. The reflection was carried out by suggesting the CEP approach with CIPI strategy to draw the students' attention. 33 students attended the class in the Cycle II and all of them were present in the Cycle III. For the sub-indicator of following the learning process, there were 4 students succeeded by coming to the class 10 minutes earlier. The cause and reflection of this sub-indicator were similar to the previous one. In cycle II, 15 students completed and increased to 35 students in the Cycle III. For the sub-indicators of owning the learning devices, there were 20 students succeeded in the Cycle I by completing their learning tools such as Student Worksheet, chemistry books, stationery, and notebooks. Most students thought that the Student Worksheet is sufficient for learning source. The teacher then gave a reflection on why they should look for other sources like chemistry books, or internet sources. In the second cycle, the number rose to 30 students and 33 students in the Cycle III. For the sub-indicator of home study, 23 students completed by studying at home like deepening the material, doing the assignments, learning before having tests, and reading the materials. Most of them used to study only when they had an assignment. The reflection was about the teacher multiply the assignment and informed the next topic for the next lesson. However, only 10 students succeeded because they did the tasks at school and forgot to fill their diary. The given reflection emphasized on the diary filling at the end of each meeting. In the third cycle, 20 students completed but the same problem remained. Therefore, the teacher should check every student's diary about the tasks assigned.

Second, the indicator of tenacity in dealing with problems. For the sub-indicator of attitudes toward difficulties, 9 students in Cycle I completed by being responsive in asking and responding opinions from teachers or friends when having difficulty in understanding the materials. Most students were accustomed to passively following the class, so, the reflection was done by

encouraging the students to actively involved in the classroom activities. In the Cycle II, there were 17 students succeeded. The rests were hesitant and afraid of making mistakes while either responding or asking questions. The teacher provided reflection so that the students could respond both intentionally and spontaneously. Thus, the observers and teacher knew the development of passive students. In the Cycle III, there were 28 students completed. For the sub-indicator of effort to overcome difficulties, 10 students succeeded in the Cycle I by discussing with friends in a group, different groups, different classes and teachers, then looking for reference sources from books or the internet. Nevertheless, many of them were silent and passively waited for their friends to be active in overcoming difficulties. The reflection was given to direct students enlivened the class discussion, resulting in 28 students succeeded on the Cycle II. However, silent students remained there. The teacher then suggested the active students help the passive ones in the discussion. Finally, 36 students succeeded in the Cycle III.

Third, the indicator of interest and attention to learning. For the sub-indicator of classroom habits, there were 25 students in the Cycle I succeeded by sitting and paying attention to the teacher who explained the materials for the lab activities. However, a lot of them only paid attention to the communication device they brought instead of the teacher. The teacher then gave a reflection by inviting the students to listen and respect to the person in front. 30 students succeeded in the Cycle II and all of them succeeded in the Cycle III. For the sub-indicator of spirit in following learning, 14 students completed by having two-way discussion extended by a question and answer session. Nevertheless, many students did not join the presentation and the presenting group only had one representation to speak while the others are silent. Therefore, the reflection was given to encourage all the presenting group members to actively involve in the presentation. In the Cycle II, 25 students completed. The Q and A session was quite good but lacked responses. The reflection was carried out in order to inspire the students to add or refute answers, resulting in livelier Q and A session. Finally, 31 students succeeded in the Cycle III.

Fourth, the indicator of learning achievement. For the sub-indicator of achievement willingness, 25 students in the Cycle I completed the threshold by doing assignments, submitting on time, doing individual and group assignments, and actively asking or answering questions eit-

her from the teacher or friends. The result was due to many students did not complete and submit the tasks on time. The teacher reflected on reducing the score for those who did not do the assignments and submit them on time. In the cycle II, 31 students completed and went up to 36 students in the Cycle III. For the sub-indicator of learning outcomes obtained in the Cycle I, 19 students completed having their score ranging from 80-100 on deepening the colloid topic. They got their answers wrong on the conclusion part, thus, a further discussion on the matter was done. There were 23 students in the Cycle II completed. The students found it difficult to answer the questions of colloid properties and the use of colloid for industrial field. The reflection was conducted through remedial, resulting in 21 students succeeded in the Cycle III.

Fifth, the indicator of learning independence. For the sub-indicator of tasks completion, there was no student in the Cycle I completed it. They could not score 80-100 on the presentation made. This was because they have never made presentation materials before. Therefore, the teacher performed the reflection by explaining each format and terms given. In the Cycle II, 20 students completed it. The same reflection was done and the number went up to 35 students completed in the Cycle III. For the sub-indicator making use of the out-of-class time, there were 6 students succeeded by taking the time to study chemistry through discussion, working on and practicing chemistry question and going to the library to borrow chemistry books. But, most students chatted in the classroom rather than read chemistry books. The teacher then gave the reflection by asking the students questions about their preparation at each meeting. In the cycle II, 17 students completed. They forgot to fill in the diary and discuss the assigned tasks at home. The reflection emphasized on the importance of filling in the diary about their daily classroom activities and submitting it at the end of the lesson. Finally, 22 students succeeded in the Cycle III, in which the teacher did not assign many tasks and only improve the products in the cycle II. Thus, the students just made notes and went to the library to borrow chemistry books.

CONCLUSION

Based on the result of research and discussion, it concluded that the CEP and CIPI strategy could increase the students' entrepreneurial interest in the Cycle I 51,17% to 72,16% in the Cycle II and 81,10% in the Cycle III, and learning

motivation in the Cycle I 56,08% to 68,21% in the Cycle II and 76,32% in the Cycle III. Therefore, all the indicators studied such as the pleasure of interest, participation, awareness, willingness, attention to an object there has been a significant improvement in the ability of students.

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ENHANCING K-10 STUDENTS' CONCEPTIONS THROUGH COMPUTER SIMULATIONS-AIDED PDEODE*E (CS-PDEODE*E) ON NEWTON'S LAWS

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ABSTRACT

The aim of this study was to enhance K-10 students' conceptions through Computer Simulations-Aided PDEODE*E (CS-PDEODE*E) on Newton's Laws. The PDEODE*E is a worksheet consisting of seven stages, which are Predict (P), Discuss (D), Explain (E), Observe (O), Discuss (D), Explore (E*) and Explain (E). The computer simulations could support learning via PDEODE*E worksheet by presenting physics' phenomena. The Newton's Laws focused on forces and Newton's First Law. The research method used the 4D (Define, Design, Develop and Disseminate). The research sample included 30 K-10 students (15 boys and 15 girls, with the average age of 16 years-old). The students' conceptions were identified through a Four-Tier Newtonian Test (FTNT) as pre- and post-test. In the developing phase, we acquired the product of computer simulations and PDEODE*E worksheet. In the disseminating phase, the value of effect size was 0.85 in the "large effect" of classification and tcount>ttable, thus, CS-PDEODE*E was more effective than CS-POE. The decisions succumbed that the students' conceptions could be enhanced via PDEODE*E based computer simulations.

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Keywords: CS-PDEODE*E, Newton's Laws, students' conceptions

INTRODUCTION

In excess of the past two periods, a countless arrangement of educational investigation has been focused concerning the study of concepts and complications of physic concepts (e.g. Gunstone et al., 2009; Wenning, 2008; Rutten et al., 2012), keeping in mind that concepts are essential construction slabs of understanding (e.g. Can & Boz, 2016; Majidi, 2014; Seung & Bryan, 2010). A compacted understanding of concepts results in a consequential deed in facilitating students improve their understanding, spreading over accurate concepts to problematic explaining, and

consequently progressing students' knowledge and capability (e.g. Liu & Fang, 2016; Rahmawati et al., 2017). Nevertheless, students repeatedly have misguidedly shaped conceptions or incomprehension the rudimentary understanding they study formerly using different concepts (Saifullah et al., 2017). Therefore, conceptual misunderstanding is an actual matter for students, particularly apprentice students and frequently consequences in deprived or incorrect understanding and construction. Studying students' conceptual misunderstandings can be a strong and challenging way to the solution (e.g. Oliver et al., 2017; Liu & Fang, 2016; Larkin & Jorgensen, 2016; Waldrip & Prain, 2012).

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In physics education, students' misunderstandings have been found out in numerous concepts of physics such as force, acceleration, adiabatic, motion, series and parallel circuits, mass, weight, hydrostatic pressure, and mechanics (e.g. Liu & Fang, 2016; Wijaya et al., 2016; Poutot & Blandin, 2015; Leinonen et al., 2012; Bayraktar; 2009; Ipek & Calik, 2008; Bharambe, 2014). Force, acceleration, motion, mass, and weight are the concepts employed in the learning of Newton's Laws. This research gripped the forces (gravity force, normal force, friction force) and Newton's First Law. These concepts are imperative because Newton's Laws are rudimentary concepts in physics. These fundamental concepts must be taught to students to learn further physics.

To accomplish that resolve, teachers must diminish students' misunderstandings. Ipek & Calik (2008) elucidated that students' misunderstandings have been overcome through insufficient sources such as tutoring in which there was no linkage between the taught concepts. This old teaching method is an extent to convert concepts and modify imperfections of students' understanding in physics yet they incline to disregard the possibility that the students' insight is perhaps dissimilar than that of the educators (e.g. Al-Amoush et al., 2014; Kurki-Suonio, 2011; Von Glasersfeld, 2012). Further investigation on these concerns could be substantiated very useful for improving instructional forms, also, for planning and increasing different learning situation (e.g. Caleon et al., 2018; Anderson & Moeed, 2017; Boyer, 2016; Nieminen et al., 2013; Rutten et al., 2012). The fee was recognized by tutors as an obstacle in directing students to comprehend a linkage between their scientific understandings and everyday environment (e.g. Mangiante, 2018; Samsudin et al., 2017; Dudu, 2017; Jamieson & Radick, 2017; Anderhag et al., 2015; Costu, 2008). In fact, generating a connection between scientific understanding and everyday surrounding might heighten students' understanding.

Aiming for that reason, an investigation by Samsudin et al., (2017) revealed that PDEODE*E worksheet was successful in civilizing students' conceptual understanding and changing their misunderstanding on the magnetic field. The PDEODE*E is a worksheet involving seven stages, which are Predict (P), Discuss (D), Explain (E), Observe (O), Discuss (D), Explore (E*) and Explain (E). Through tallying Explore (E*) in PDEODE*E, it was more beneficial

particularly to deliver conceptual change and to improve conceptual understanding of physics students. Consistently, we employed examination sheet distinctly to explore concepts in instruction to change students' misconception concerning scientific conception correctly. In advance of exploration activities, students could find their own misconceptions. The exploration activities could be supported by using computer simulations. Computer simulations had an accommodating effect on students' capability to estimate and designate phenomena. Computer simulation assistance picked as the observation object considering its advantage to expedite the learning of abstract concepts, which heightened the students' achievement implicitly (e.g. Gunawan et al., 2017; Samsudin et al, 2016; Chen et al., 2013; Bayrak, 2008). The K-10 students have studied Newton's Laws at Junior High School, however, 89.07% of them had misconceptions. This could be problematic for the K-10 students to study the more complex Newton's Laws in Senior High School. In addition, they might not be able to learn further physics concepts. Therefore, the purpose of this study was to enhance the K-10 students' conceptions through Computer Simulations-Aided PDEODE*E (CS-PDEODE*E) on Newton's Laws.






METHODS

The Research and Development (R & D) method was adopted for this research. Moreover, the 4D model (Define, Design, Develop and Disseminate) was used as one type of R & D (Samsudin et al., 2017; Fratiwi et al., 2017). The 4D model was an unpretentious method in the procedure of evolving a product (Irawan et al., 2018). At the phase of Define and Design, the PDEODE*E worksheet and computer simulations were defined and designed. At the stage of Develop, we established the worksheet and computer simulations based on the design. Moreover, at the Disseminate phase, we estimated the dissimilarities between CS-PDEODE*E and CS-POE to distinguish which was more in effect. The PDEODE*E and POE worksheet were validated by four experts in physics education. The value of PDEODE*E validity was 1.00 and the POE validity was 0.96. Before the learning process, the students had a pre-test of sixth Four-Tier Newtonian Test (FTNT). After the pre-test, treatments (CS-PDEODE*E) were done. Next, the students

undertook a post-test with the identical problem as the pre-test. The FTNT practice was to record the students' conceptions. The evaluation tool was established in Fratiwi et al. (2017) before being adopted for the pre-test and post-

test (see Figure 1). The test items were schematized in the formulation of four-tier test items recognized as the two-tier test. The FTNT was validated by the four experts in physics instruction.

6.1 A student throws a ball vertically upward by giving a force (F) on the ball (assuming the air resistance is negligible). The force that works on the ball when the ball reaches its highest point (before moving down) is... .

a.  b.  c.  d.  e. 

6.2 Are you sure with your answer in 6.1?
a. Sure b. Not sure

6.3 Reason for answer in 6.1:
a. Weight is always exists as long as the object is in affected by gravity.
b. The upward thrust force keeps working on the object although it is smaller than the gravity.
c. There is no force after reaching the highest point because the ball is not moving.
d. The force of thrust and gravity is an action-reaction force.
e.

6.4 Are you sure with your answer in 6.3?
a. Sure b. Not sure

Figure 1. The example of FTNT

The samples were 30 K-10 senior high school students (15 boys and 15 girls having their average age of 16 years-old). The students completely took into the pre-test and post-test, moreover, they were divided into two groups. One group using CS-PDEODE*E and the other employed the different practice CS-POE with the identical scoring system on the pre-test. We chose the POE worksheet since it is the origin of the PDEODE*E. In other words, the PDEODE*E was developed from the POE. Therefore, we expected to compare the effect of the original worksheet (POE) with the modified worksheet (PDEODE*E). The students' conceptions classified into five types of students' answers on the FTNT. The types and scores of each student's conceptions are presented in Table 1. We graded the students' conceptions after the pre-test and post-test (Samsudin et al., 2017).

Table 1. The Score of Students' Conception

Students' Conception	Score
Sound Understanding (SU)	2
Partial Understanding (PU)	1
Misunderstanding (MC)	0
No Understanding (NU)	0
No Coding (NU)	0

RESULTS AND DISCUSSION

For the results and discussion, we divided on behalf of four phases as the 4D model (Define, Design, Develop and Disseminate). As of the study, the results and discussion section designated as follows.

Define

The POE has queried students' understanding by demanding students to accomplish three

errands, which are Predict, Observe, and Explain (e.g. Haysom & Bowen, 2010; Costu et al., 2010). Grounded on the POE, Susto & Krstic (2010) has been advanced the PDEODE. Furthermore, Samsudin et al. (2017) have been settled the PDEODE*E by tallying Explore (E*) stage to be a beneficial addition especially to afford conceptual change and to improve students' conceptual understanding. The PDEODE*E worksheet comprised seven steps as shown in Table 2 (Samsudin et al., 2017).

Table 2. The Step Description in PDEODE*E Worksheet

Steps of Worksheet	Descriptions
Predict (P)	The teacher reached a conceptual field of the students through the worksheet and asked them to predict self-sufficiently as to what should enhance.
Discuss (D)	The determination gifted to discuss and picket students discriminated in their group.
Explain (E)	The students in individual group discovered to scrunch a pacification and assumption of the matter, and to current their concepts to other groups. Therefore, those who finished working in their groups commenced an applied investigation and individually predicted their observations coarsely.
Observe (O)	The students observed deviations in the incidence and the teacher pointed them to the importance of observations applicable to the learned concepts.
Discuss (D)	The students tried to prove their predictions through the unpretentious observations accomplished in the preceding step. At this step, the students were demanded to investigate, subordinate, difference, and criticize the findings with their group mates.
Explore (E*)	Students explored the problem by themselves to deliver conceptual change and to improve conceptual understanding.
Explain (E)	The students dared totally discrepancies in the mid of observations and predictions.

In favor of the use of PDEODE*E worksheet, the researchers employed the computer simulation. The computer simulation is a media director to assist students' vigorous contribution in overcoming problematic circumstances in terms of cost and time allotment both in the classroom or the physics laboratory (Rutten et al., 2012). The simulations delivered an association between students' prior understanding and the learning of

innovative physical concepts (Osman et al., 2017; Mattheis, 2015), students' progress of scientific understanding reorganized their misconceptions.

Design

According to the seven steps in PDEODE*E (Predict, Discuss, Explain, Observe, Discuss, Explore and Explain), the worksheet design is shown in Figure 2.

PDEODE*E WORKSHEET

Name :

Date :

Groups :

Topic :


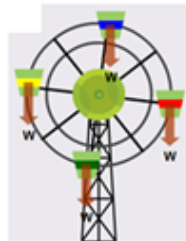
- 1. Predict**
.....
.....
- 2. Discuss and Explain**
.....
.....
- 3. Observe**
.....
.....
- 4. Discuss**
.....
.....
- 5. Explore**
.....
.....
- 6. Explain**
.....
.....

Figure 2. The Design of PDEODE*E Worksheet

The computer simulations designed by the researchers were adjusted with the students' misconceptions. This was due to many computer simulations' incapability to enhance

students' conceptions and change their misconceptions. The design of computer simulations or storyboard is shown in Figure 3.

Title : The Types of Forces
Frame : 1

Weight
Weight (w) is the force exerted on a body by gravity and its direction always toward the center of the earth.

Formulation:
 $w = mg$
 thru: w = weight (N)
 m = object mass (kg)
 g = gravitational eceleration (9,8 m/s²)

[Next](#)

Descriptions

- The title "The Types of Forces" is large with dark blue on the left.
- In the first view, the two images are already rotating. In the picture of the earth, the weight direction is always toward the center of the earth, whereas in the image of the strait, the weight direction always goes down. The weight symbol uses w.
- The next button functions is to continue the simulation at a next frame.

Figure 3. The Design (storyboard) of Computer Simulation


Develop

The design of PDEODE*E worksheet and computer simulations were developed. The deve-

loped of PDEODE*E worksheet and computer simulations are presented in Figure 4 and Figure 5.

PDEODE*E WORKSHEET

Name :
 Date :
 Groups :
 Topic : **Newton's First Law**



1. Predict
 Predict what will happen to the beam when piston has not been pressed and has been pressed? State and explain the reason for your predictions!

.....

.....

2. Discuss and Explain
 Discuss your prediction and reason in your group and explain your reason in detail!

.....

.....

3. Observe
 Observations that occur on the beam when piston has not been pressed and has been pressed! What will happen? Is there a difference between the two occurrences? State your observations!

.....

.....

4. Discuss
 Why does this happen? Discuss with your group! Then explain your reason in detail!

.....

.....

5. Explore
 Do a further exploration of the observations you get using the computer simulation! Write the conclusion on the exploration sheet below!

.....

.....



6. Explain
 Compare your observations, explorations with your predictions! Is it the same or different? Explain your reason! What can you conclude from the phenomena? Please write your reason below!

.....

.....

Figure 4. The Example of PDEODE*E Worksheet

THE TYPES OF FORCES

Weight
 Weight (w) is the force exerted on a body by gravity and its direction always toward the center of the earth.

Formulation:
 $w = mg$
 thru: w = weight (N)
 m = object mass (kg)
 g = gravitational acceleration (9,8 m/s²)

[NEXT](#)

Figure 5. The Example of Computer Simulations

Disseminate

In the disseminate phase, the researchers described the result of this research. The researchers created the graph to show the

students' scores at the pre-test and post-test for each sub-concept (C1-C6) and the all of the sub-concepts. The graph shows in Figure 6.

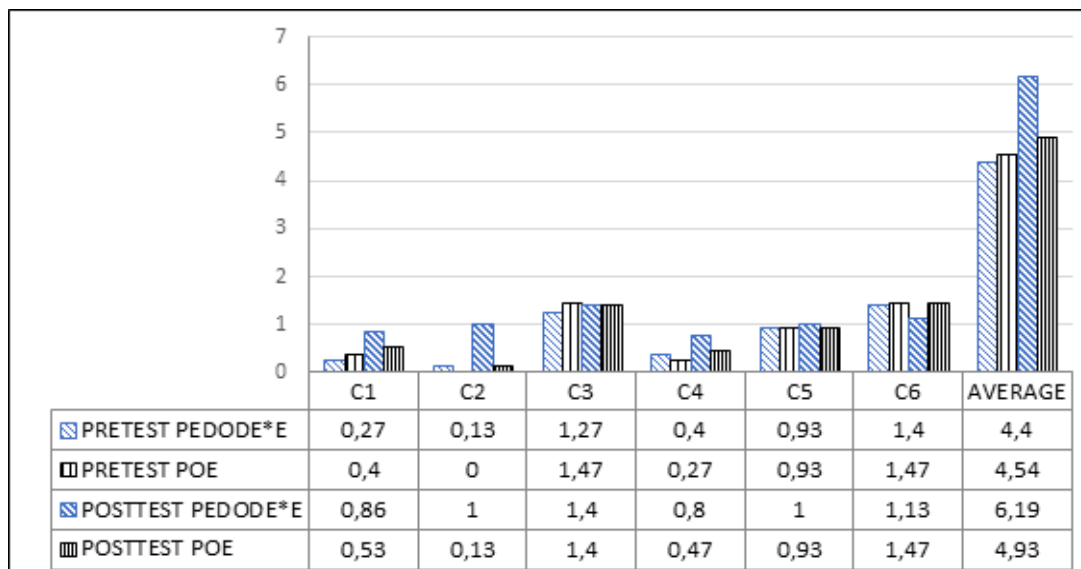


Figure 6. The Graph for Students' Scores at Pre-test and Post-test

The sub-concept of C1 and C2 were about the balanced forces, the C3 was about inertia, and the C4-C6 was about types of forces. Figure 6 is the graph of pre- and post-test after using the CS-PDEODE*E and CS-POE. At the post-test, the students' understanding in every sub-concept using CS-PDEODE*E was higher than those adopting the CS-POS, especially in the C2. For example, at the pre-test, most students assumed that there was no force after reaching the highest point because the ball does not move (Figure 1). For that case, when the ball reaches its highest point (before moving down), weight always exists as long as the object is in affected by gravity.

In Figure 6, as seen in the pre-test, the average scores of students' understanding were almost same (4.40 and 4.54). After the treatment used the CS-PDEODE*E and CS-POE, the average scores increased. The students employing the CS-PDEODE*E obtained the score of 6.19 and those using CS-POE obtained the score of 4.93. At the post-test, the students with the CS-PDEODE*E got a bigger average score than those with the CS-POE. To know more about the impact of different treatments on enhanced students' conceptual understanding, the researchers employed the effect size. Correlated to Sinaga & Feranie (2017) and Samsudin et al (2017), the effect size aided recognized the effect of differences in worksheet between the experimental and control class on enhanced students' conceptions. The

Glass' delta was used to calculate the effect size as presented in Table 3.

Table 3. The Effect Size of the Data

Treatment	Average Scores	Std. Deviation	Glass's Delta
CS-PDEODE*E	6.19	2.01	0.85
CS-POE	4.93	1.49	

At Table 3, the significance of effect size was 0.85 classified as "large effect". This significance indicated that the CS-PDEODE*E was more effective than the CS-POE to enhance the students' conceptual understanding. Furthermore, the researchers tested the hypothesis using the t-test. It aimed to prove the differences in conceptual understanding between the CS-PDEODE*E group and CS-POE group. Based on the calculation, acquired the $t_{count} = 5.339$ and $t_{table} = 2.048$ ($\alpha = .05$). We could see that the $t_{count} > t_{table}$, thus, there was a significant difference between the students with CS-PDEODE*E and those with CS-POE. The outcome is correlated with Samsudin et al (2017) who stated that the PDEODE*E worksheet was an effective aid for overcoming va-

rious misunderstandings and enhancing students' understanding. Moreover, Kaniawati et al. (2016) concluded that computer simulations could increase students' conceptions. Nevertheless, there was still less significant improvement in students' conceptual understanding. This is correlated to Oliver et al. (2017), Liu & Fang (2016), Larkin & Jorgensen (2016) and Waldrip & Prain (2012) that students' misconceptions can be strong and be challenging on the way to truthful.

CONCLUSION

Based on the research findings, we could associate the CS-PDEODE*E with CS-POE to enhance the students' conceptions of Newton's Laws, especially in the concept of balanced force. The outcome was an indication that value of effect size was 0.85 categorized as "large effect". Furthermore, the result of the t-test showed that the $t_{count} > t_{table}$. This indicated that the CS-PDEODE*E was more effective and had significant differences than the CS-POE. Although the CS-PDEODE*E provided a large effect on enhancing the students' conceptions, the PDEODE*E worksheet and computer simulations remained to have insufficiencies essential to be overcome. Moreover, the CS-PDEODE*E could be developed by other researchers for other physics concepts. The CS-PDEODE*E could be used as a media of learning to show the physics phenomena to students and foster them to discover new concepts.

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STUDENTS' SCIENTIFIC EXPLANATION IN BLENDED PHYSICS LEARNING WITH E-SCAFFOLDING

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ABSTRACT

This purpose of this research was to analyze the influence of blended physics learning with e-scaffolding on the gas kinetic theory to the students' scientific explanation. This research used quasi-experimentation with one group pretest-posttest design. The population of this research included the grade XI students of Natural Sciences in SMA Negeri 1 Bangkalan. The proposed hypothesis was that the blended physics learning with e-scaffolding affected the students' scientific explanation. The research results indicated that the students' scientific explanation ability significantly increased after they experienced blended physics learning with e-scaffolding. All aspects of scientific explanation, that was the claim, evidence, and reasoning improved significantly.

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Keywords: blended learning, e-scaffolding, scientific explanation

INTRODUCTION

The innovation in learning should be carried out to improve the low category of the evaluation test referring to the result of PISA Indonesia 2015. One of the ways to increase the score of PISA is growing the competency of arguing or giving a scientific explanation. Besides, the learning in Indonesia that applies 2016 National Curriculum (revised version of 2013 Curriculum) also intends to implement the scientific approach that cannot be separated from the scientific investigation and demands the good scientific explanation ability.

Engaging students in scientific practice may help refine their viewpoint of science or physics. Helping students engage in scientific practice may shift their view of science as a static set of facts to science as a social process in which

knowledge is constructed. Furthermore, assisting students to construct a deeper understanding of content knowledge would engage them in scientific explanation (McNeill & Krajcik, 2008). As an argumentative practice, engaging science learning could promote students' critical thinking, reflection, and evaluation of evidence (Bathgate et al., 2015). Besides, the scientific competencies proposed by PISA focus on the ability needed in students' life in accordance with students' involvement in giving the scientific explanation.

Wang (2015) stated that one of the primary purposes of science education is preparing the students to synthesize and evaluate the scientific explanation. Meanwhile, the scientific competencies suggested by PISA focus on the ability needed in the students' life. Tsai (2015) has investigated how such scientific competency can be improved using online argumentation. The research results showed that the use of online argumentation could enhance the students' scores in the scientific competency of PISA. Argumentati-

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on teaching consisting of specific process, online assistance and scenario of argumentation conflict can help upgrade the students' scientific competencies of PISA.

The microanalysis of student discourse by Von Aufrechner et al. (2008) showed that: (a) students draw on their prior experiences and knowledge when engaging in argumentation; (b) such activity enables students to consolidate their knowledge and elaborate their science understanding at relatively high levels of abstraction. The results also suggest that the students could acquire a higher quality of argumentation consisting of well-grounded knowledge with a relatively low level of abstraction. Furthermore, the findings indicate that the primary indicator of students' familiarity and understanding of the task content determine whether a high quality of argument is likely to be attained or not. The implication of developing argumentation in the classroom is needed to consider the nature and extent of students' content-specific knowledge, also, their experiences before asking them to engage in argumentation.

Braaten & Windschitl (2011) argued that the conceptualization of a clearer scientific explanation for science education is essential to realize the vision of science education reform. Therefore, by improving the scientific explanation ability, the score of PISA could increase. The scientific explanation framework includes three components, namely claims, evidence, and reasoning. The claim makes a statement or conclusion that addresses the original question or concerns about the phenomenon. Evidence supports student claims using scientific data. Data can be obtained from investigations or from other sources, such as observation, reading material, or archival data, and the need to be precise and sufficient to support such claims. Reasoning connects claims and evidence and shows why data is counted as evidence to support the claim. When making this connection, students must often use the precision of scientific principles.

The physics learning relevant to the nature of Natural Sciences needs an inquiry process. This process enables students to directly involved in a learning process. Through this activity, it is expected that students acquire scientific attitudes and after passing a sequence of learning, students could make their own conclusion. The scientific explanation a teacher presents may vary in its implementation. This would determine the practicum quality done by students. The instructional practices conducted by teachers could influence scientific explanation learned by students

(Berland & Reiser, 2009). The scientific investigation usually involves relevant evidence, logical reasoning, thoughts in arranging the hypothesis, and the explanation to understand the collected proofs.

Problem Based Learning (PBL) is a learning model designed to solve the presented problems. According to Arends (2012), PBL is a learning model that exhibits various authentic and meaningful problems for students, functioning as a stepping stone for investigation. The PBL model is a learning model that helps students develop their activeness in an investigation. Besides, the PBL model could develop thinking skill to solve the problems.

Based on the explanation from some experts, it concluded that the characteristic of such learning model emphasizes on the problem-solving. The problems should be ill-structured and contextual. Students are demanded to actively search the information from all sources related to the faced problems. The analysis results are later referred to as the problem solution and communicated to others.

To facilitate students in searching for information, PBL could be combined with online learning. This combination may support students to be more active in finding a solution. A learning program that mixes traditional in-class learning components and e-learning components is called hybrid learning or blended learning (Kim, 2008).

Some benefits of blended learning are its potential to bring out the variations of learning style, enrich the learning experience, and increase the consistency of topic and quality of given training. Blended PBL model is one of the blended learning models in the physics learning that has those benefits. Thereby, the goal of improving the scientific explanation ability could be accomplished through blended physics learning activities.

The term scaffolding was introduced by Wood, Bruner, and Ross in 1976 which means mentoring or another assistance given in the learning setting to help students reach an understanding sequence that is impossible for them to achieve without help (Raes et al., 2012).

The way to facilitate various levels of students' pre-conception in a class called scaffolding. The scaffolding between different ability levels of students would have differential impacts (Belland et al., 2011). Procedural scaffolding is assistance utilizing the available resources and tools (Yu et al., 2013). External scaffolding may be the way of supporting students' construction of evidence-based arguments (Belland et al., 2008).

Procedural Scaffolding helps the students

use the resources. It reduces the cognitive load, enables participants to focus on the task rather than investing the cognitive resources in the mechanism of procedure and navigation. The assisting system in Microsoft Word, for example, enables students to search the information in a specific function and the link of the related field and gives the "office assistant" identifying the steps needed to operate the program features. The navigation map found on many Web pages is procedural scaffolding (Grabe&Grabe, 1998).

Besides, the technology always rapidly escalates and influences the human's life very much. For instance, the diverse kinds of technology employed to support the human's life sustainability in 2000 decades develop fast to be more complicated as faced today. The technology development also impacts many fields such as health, economy, social and culture, information and communication, education, and the others.

E-scaffolding in this research is a virtual collaborative and comprehensive learning tool. This media can facilitate the collaboration of small duty until long semester-task among students in a class, with students from different schools, between students and teachers, as well as between teacher and teacher via the internet. From 118 scaffolding occurrences noted, the majority of assistance are procedural and conceptual (Way & Rowe, 2008). These are the differences of this research from the previous studies; the concept of procedural e-scaffolding applied in blended PBL model will be able to train and improve the students' scientific explanation ability.

Mustajab & Sahala (2014) stated that one of the physics sub-materials in physics lessons is the ideal gas. This ideal gas sub-materials is abstract and frequently cause errors in solving the ideal gas problems. A research conducted by Mahmudah (2013) on 10 students of XI IPA Grade in SMA Negeri 7 Surakarta, the academic year 2012/2013 found the kind of mistakes made by the students in solving problems on the subject matter of gas kinetic theory; 56% of it was concept errors and 44% of it was miscalculations. Yoto (2015) stated that gas kinetic theory is abstract and microscopic. Similarly, the scope of this study relates to invisible objects. Therefore, learning the kinetic theory of gas in SMA should be supported by the media that could help students understand the materials so that reasonable scientific explanation is obtained. Therefore, an appropriate learning strategy is needed to learn the material of gas kinetic theory. In short, this

research aimed to analyze the students' scientific explanation ability after experiencing blended physics learning with e-scaffolding.

METHODS

This study was quasi-experimental research using only experimental class for the research without control class. The research design used was One Group Pre-test – Posttest Design. In this design, the observation was conducted twice; before the experiment (pre-test) and after the experiment (post-test). The populations of this research were the XI IPA students in SMA Negeri 1 Bangkalan and one class as the research sample. The following is the design adopted in this research.

$$Y_1 \longrightarrow X \longrightarrow Y_2$$

(Sudjana & Ibrahim, 2001:35)

Note:

Y_1 : Giving pre-test

Y_2 : Giving post-test

X: The type of treatment

In this stage, the improvement of students' scientific explanation ability was measured through the pre-test and post-test, before and after implementing the blended physics learning with e-scaffolding. The instruments used were in the form of questionnaire test made up of ten questions. After going through the empirical test process, the ten questions were declared valid and reliable. Thus, the ten questions were tested during a scientific explanation test.

The N-gain Score

The data of pre-test and post-test were analyzed using n-gain score (the normalized gain). The interpretation criteria of the normalized gain score are presented in Table 1.

Table 1. The Criteria of Interpretation of Normalized Gain Score

Score	Interpretation
$\geq 0,7$	High
$0,7 > \geq 0,3$	Moderate
$< 0,3$	Low

(Hake, 1998)

The T-gain Test

The t-gain test was used to know the significance of the students' scientific explanation skill

improvement after experiencing the blended physics learning with e-scaffolding. The analysis results of the t-gain test were obtained by analyzing the results of pre-test and post-test. The steps to analyze the t-gain according to Arikunto (2010) are as follow:

1. Arranging the hypothesis
2. H_0 : the improvement of the students' scientific explanation ability is not significant
3. H_1 : the students' scientific explanation ability increases significantly
4. Determining the gain score (d) by finding the difference between the results of post-test and pre-test
5. Determining the gain mean (Md)
6. Determining t score.
7. Drawing the conclusion of tcount and ttable at the significant level of 0.05. If the $t_{count} < t_{table}$, the H_0 is accepted and if the $t_{count} > t_{table}$, the H_0 is rejected.

RESULT AND DISCUSSION

The results of pre-test showed the students' pre-conception in the domain knowledge. After having the pre-test, the students experienced the blended learning with e-scaffolding for Gas Kinetic theory. At the end of learning,

the post-test was conducted and the scores were gained. Pre-test and post-test scores are presented in Table 2.

From Table 2, it knows that the pre-test mean of students' claim was 53, the pre-test mean of evidence was 49, and the pre-test mean of reasoning was 43 so that the mean of the students' pre-test scores was 48. The Table 2 also indicated that the post-test mean of the students' claim was 89, the post-test mean of evidence was 85, and the post-test mean of reasoning was 80 so that the mean of the post-test scores was 85. These scores increased from pre-test for all aspects of the claim, evidence, and reasoning to the final scores.

Subsequently, the results of pre-test and post-test were analyzed using the n-gain scores to know the improvement of the students' scientific explanation and all aspects measured through pre-test and post-test before and after learning. The analysis results of the n-gain scores showed the significant improvement in all aspects of students' scientific explanation. The n-gain score for the claim, evidence, and reasoning was 0.77, 0.71, and 0.65 respectively. The n-gain score for the scientific explanation was 0.71. Based on Table 1, all improvements were considered high except for the reasoning.

Table 2. The Students' PreTest and Post-Test Scores on Scientific Explanation

The Test Results of Scientific Explanation	Pre-test						Post-Test							
	Score			Value			FS	Score			Value			FS
	A	B	C	A	B	C		A	B	C	A	B	C	
Mean	16	15	13	53	49	43	48	27	25	24	89	85	80	85
SD	6,2	3,2	3	21	11	10	11	2,9	3,3	3,4	9,8	11	11	8,3
Maximum	29	20	20	97	67	67	74	30	30	30	100	100	100	100
Minimum	10	10	10	33	33	33	33	22	20	19	73	67	63	68

Note: A = Claim; B = Evidence; C = Reasoning; FS = Final Score; SD = Standard Deviation

The results of pre-test showed that the students' mean for each indicator of scientific explanation was still low which are the mean of claim (53), the mean of evidence (49), the mean of reasoning (43), and the final mean (48). From those three indicators, the mean of claim was the highest score compared to the other two indicators. This case showed that the students have not been able to give a statement of answer, present and show the evidence to support their statement of answer, and relate the understanding of the topic to the obtained evidence to support their answer in the reasoning part. Thereby, the results of pre-test indicated that the students' scientific

explanation ability was less good. For the students to be able to complete the performance better, helping students understand the rationale behind a particular scientific inquiry practice is important in science (Mc Neill & Krajcik, 2008). Mc Neill (2011) investigated students' views of three contexts of explanation, argument, and evidence. When they were asked about their science class, most likely answered 'I don't know'. Even though they had enough learning sources both from everyday knowledge and scientific knowledge, they were unsure how to use the sources in their science class. Therefore, building the expla-

nation means showing the ability to provide the right explanation and understanding equipped with the evidence.

The post-test results after treatment showed that the mean of claim indicator increased to 89, the mean of evidence indicator also enhanced to 85, and the mean of the students' reasoning also improved to 80. This indicates that the final mean of the students' scientific explanation also upgraded to 85. The results of the t-gain test showed that there was a high and significant scientific explanation ability of the students.

The post-test result after the treatment of e-scaffolding in blended learning supported the students to learn independently and collaboratively. E-scaffolding individually bridged the students' zone of proximal development with the faced challenge. Besides, e-scaffolding guided them in group and face-to-face learning.

There are some research findings supporting this research results. Kim et al. (2017) found that students who learned with the scaffolding assisted by a computer in PBL context had better performance than those who did not use scaffolding. Supporting students in writing scientific arguments to explain phenomena were more successful by the context-specific curricular scaffolds, but only if teachers' provided explicit general domain for the framework of claim, evidence, and reasoning (Mc Neill & Krajcik, 2009). Yu et al. (2013) revealed that the use of procedural scaffolding supports students in the learning activity. Those who used procedural scaffolding gained better outcome than those who did not (Yu et al., 2013). Amelia et al. (2016) also showed that the procedural scaffolding applied in specific class could enhance the learning achievement. Hsu et al. (2015) told that scaffolding is very helpful for the process of investigation and development of conceptual understanding.

CONCLUSION

Blended physics learning with e-scaffolding improved the students' scientific explanation. The improvement occurred in all aspects of scientific explanation namely claim, evidence, and reasoning. The highest improvement occurred in the claim aspect. These two aspects, claim and evidence, grew significantly through collaborative activities in solving problems. In these activities, students were required to seek information and analyze them actively then communicated the solution. In the blended physics learning with e-scaffolding, the students involved in supportive

activities to help them in finding the solutions. Therefore, it is suggested that teachers should develop collaborative and supportive activities in physics learning such as blended learning to enhance students' scientific explanation.

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THE INSTRUCTIONAL-BASED ANDRO-WEB COMICS ON WORK AND ENERGY TOPIC FOR SENIOR HIGH SCHOOL STUDENTS

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ABSTRACT

This study aimed to determine the validation of Andro-web comics on Work and Energy topic. To achieve the objective, this study was designed referring to ADDIE model, i.e, Analysis, Design, Development or Production, Implementation or Deliver, and Evaluations. The Andro-web comics could be accessed using a digital comic application, Webtoon. It is downloadable in Play store or App store. The Andro-web comics is compatible with all devices including mobile devices (phone, tablet, iPod, PDA, and smartphone) and PC/Mac. Based on the expert judgment, the Andro-web comics is suitable for learning. The Instructional-Based Andro-Web Comics is alternative instructional materials for teachers to attract students' attention and help them studying easily and practically as it provides an interesting illustration with simple language. It could also be used wherever and whenever without teacher's guidance. Both teachers and students could communicate on the comment column which is available in the application without time and place limitation.

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Keywords: Andro-web, comics, webtoon

INTRODUCTION

Instructional materials contain learning materials that could help teachers and students in implementing learning process (Bingimlas, 2009). Instructional materials available in schools are generally textbooks and Student's Worksheet. Thick textbooks containing heavy materials are less interesting and make students lazy to read. The existing Student's Worksheet also unable to attract students due to its monotonous layout and brief material presentation.

The development of ICT (Information Communication Technologies) in the education world offers the effectiveness of achieving communication goals and economic efficiency such

as time, cost, and energy (Perbawaningsih, 2013). Learning using ICTs such as mobile devices (smartphones, mobile phones, iPods, and PDAs) could support the conception of learning and has been proven to increase visibility and significance in higher education (Livingstone, 2012). The use of mobile technology could also enrich students' learning experience and participation in learning process (García-Peñalvo&Conde, 2015; Fulantelli et al., 2015). However, these developments have not been maximally utilized by physics teachers in public schools in Jember.

The development of ICT currently affects interaction, learning style, and student's attitude (Slechtova, 2015). The results of the questionnaire distributed to 102 respondents in public schools in Jember indicated that 79.4% of the students use smartphones during the learning process to

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find additional materials. Therefore, it proves that ICT-based learning is highly required considering its great influence on modern learning.

Physics will be more enjoyable if it is packed in comics form. This is suitable with Hadi & Dwijananti's research (2015), who revealed that 76.47% of students were interested in using physics comics in learning process and 80.15% of students claimed that comics helped them in learning process. Abstract and complex concepts on physics, especially the topic of work and energy could be simplified through comics. Illustrative and applicable comics could be an alternative instructional materials for teachers to hold an important key of learning process which states that students must be able to relate the material studied with real life (Mulyono, 2012).

The use of comics as instructional materials could help increase student's learning interest and motivation and assists students in understanding the material easier and simpler (Williams, 2008; Lestari, 2016; Zain et al., 2013). The cartoon concept in comics is presented in an easy way to retain students' interest especially those with learning difficulties (Tatalovic, 2009). The interconnected images form the plot and make concepts easy to remember (Kumaran et al., 2009; Tatalovic, 2009).

The utilization of mobile devices such as smartphones and wireless devices in the development of commodity-based materials supports the storage of practical resources. Students can access information anytime and anywhere as needed (Lavin-Mera et al., 2009; Cavus& Ibrahim, 2009; Ligi & Raja, 2017). Students can also communicate with teachers and other students unlimited by space and time (Moura & Carvalho, 2010).

Some researchers have developed comics as instructional materials but in printed form (Tyas et al., 2015; Widyawati & Prodjosantoso, 2015). Along with the ICT development, the researchers developed the Instructional-Based Andro-Web Comics which is accessible on smartphone and personal computer as students use mobile phones and personal computers more often than the instructional materials they get at school.

Some researchers have also developed Android-based comics. Moreover, they used the most recent social media (Hadi & Dwijananti, 2015; Irwandani & Juariyah, 2016), but it is only available on mobile phones with an Android operating system and spends much internet quota since it contains autoplay video. On the other hand, the developed Instructional-Based Andro-Web Comics is not only available for mobile phones with the Android operating system, but also

for mobile phones with the iOS operating system. Additionally, it is accessible for all personal computers including Mac, because people could retrieve it through a website.

The Instructional-Based Andro-Web Comics is accessible to all people regardless of age, background, social status, cultural status, or gender. The main advantage of Instructional-Based Andro-Web Comics is its accessibility based on the needs and users' desire especially students without time and place limitation. Therefore, the learning process could not only be conducted in the classroom but anywhere.

The formulated research problem is how the validity of Instructional-Based Andro-Web Comics was. Therefore, the purpose of this development was to create valid Instructional-Based Andro-Web Comics with ADDIE (Analysis, Design, Development or Production, Implementation or Deliver, and Evaluations) model.

METHODS

The data collection techniques used was validation. The instrument of data collection was validation sheet. The data obtained by giving validation sheet and the Instructional-Based Andro-Web Comics to the validators to be assessed its feasibility, accuracy, and efficiency.

This research belonged to the Research and Development producing the Instructional-Based Andro-Web Comics on work and energy topic for tenth-grade senior high school students. The research used ADDIE (Analysis, Design, Development or Production, Implementation or Deliver, and Evaluations) model.

The reason underlying the selection of the ADDIE was due to its clear and systematic development stages in overcoming learning source problems based on students' need (Wang & Hsu, 2009). The development design of ADDIE has already been applied by other researchers such as Fajriah and Anggereini, (2016); Sudarwati et al., (2017); Sulfiah & Sulisworo, (2016) in designing and developing comics as well as online-based learning.

These were the steps of the ADDIE model used in this study: (1) analyzing students' problems during learning process and analyzing the need for developing new instructional materials; (2) designing the written teaching material concepts that suited the characteristics, needs of students, and learning objectives; (3) creating teaching materials according to the design and making the instruments for its feasibility measurement. Also, it was then validated using the formulated

instructional materials standards; (4) implementing the Instructional-Based Andro-Web Comics on the actual conditions; and (5) assessing the product consisting of both formative and summative evaluation. The formative evaluation was to determine the shortcomings of the Instructional-Based Andro-Web Comics during the learning process done at the end of weekly face-to-face. While the summative evaluation was to measure the achievement of learning objectives implemented after the development test activities ended.

These were the data processing techniques used to measure the feasibility of Instructional-Based Andro-Web Comics: (a) Data recapitulation of the Instructional-Based Andro-Web Comics into tables including indicators (I_i) and value (V_{ji}) for each validator; (b) Determining the average validation result value from all validators, in which for each indicator used the following formula:

$$I_i = \frac{\sum_{j=1}^n V_{ji}}{n}$$

I_i = the average scores for the indicator i
 V_{ji} = the data score of the validator data j to the indicator i
 n = number of validators

c) Determining the average scores for each aspect;

$$A_i = \frac{\sum_{j=1}^m I_{ij}}{m}$$

A_i = the average scores of aspect i
 I_{ij} = the average scores of the aspect i to indicator j
 m = number of indicators in aspect i

d) Determining the score of V_a or the total score of the average values of all aspect;

$$V_a = \frac{\sum_{i=1}^n A_i}{n}$$

V_a = the total average scores of all aspects
 A_i = the average scores of the aspect i
 n = number of aspects

e) Furthermore, the total value or the mean value referred to as the following Instructional-Based Andro-Web Comics costing prevalence interval and intervals:

Table 1. The Validity Level of Instructional Materials

The Value of V_a	Validity
$1 \leq V_a < 2$	Not Valid
$2 \leq V_a < 3$	Less valid
$3 \leq V_a < 4$	Fair
$4 \leq V_a < 5$	Valid
$V_a = 5$	Very Valid

(Hobri, 2010)

RESULTS AND DISCUSSION

The Instructional-Based Andro-Web Comics is instructional materials which belong to interactive multimedia in the form of digital comics available in an application named webtoon. The production of Instructional-Based Andro-Web Comics placed on the Core Competency, Basic Competency, and Indicators adjusted to the students' characteristics and materials needed.

The development of Instructional-Based Andro-Web Comics is needed by students referring to the observation and questionnaire shared in public schools around Jember indicated that the students were more interested in studying using a smartphone than a textbook or student worksheet they owned. In the learning process, a half of students were lazy to bring heavy and thick textbooks; or, they just put it on their bag without reading them since it is less interesting. Thus, it required to develop an instructional material suitable for the development of ICT and students' needs just like the Instructional-Based Andro-Web Comics.

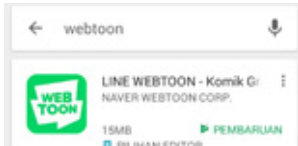
The Instructional-Based Andro-Web Comics could be an alternative choice for teachers and students to have effective, efficient, and practical instructional materials in achieving learning objectives. It was formulated to help students understand the materials easily without teacher's guidance wherever and whenever.

The Instructional-Based Andro-Web Comics consist of 12 episodes including the episode 1 about the character introduction; episode 2 about the introductory story; episode 3-8 about the materials on work and energy topic; episode 9 about the sample questions; and episode 10-12 about student discussion sheets. The Instructional-Based Andro-Web Comics could be updated anytime based on the research needs.

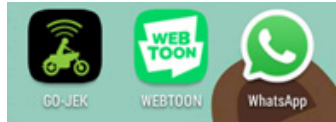
The steps to access Andro-web comics via smartphone and PC / Mac are:

a. On smartphones

1. Download the webtoon app on the playstore or app store.



2. Open the webtoon app.



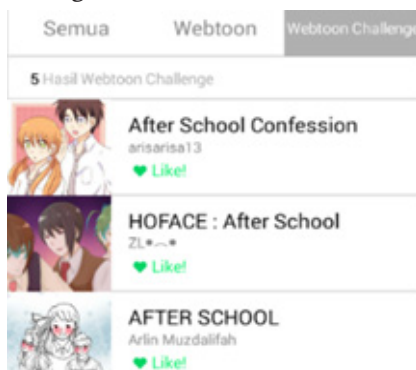
3. Click the "Challenge" option.



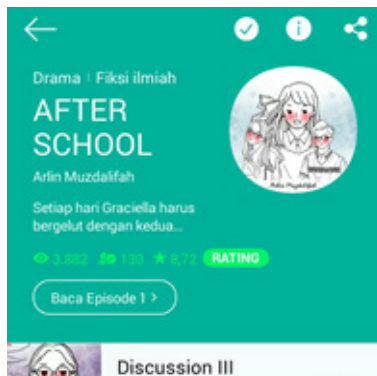
4. Click "Search". Then, type the comic title, "After School". If it is not found, type the name of the comic author, "Arlin Muzdalifah".



5. Click the button, "Webtoon Challenge" then select the target comic.



6. The Instructional-Based Andro-Web Comics entitled "After School" is accessible.



b. On PC / Mac

1. Type "Webtoon" into Google search.



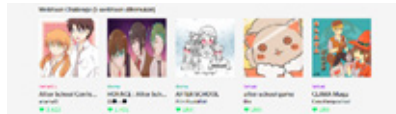
2. Select the link as shown by the picture.



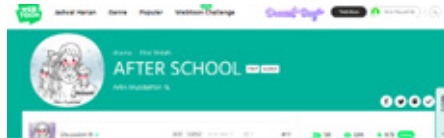
3. Click the "Search" button then type "After School".



4. Select the target comic.



5. The Instructional-Based Andro-Web Comics entitled "After School" is attainable.



The Instructional-Based Andro-Web Comics was validated by two expert validators and one user validator before being implemented to the development test. The expert validators are lecturers of Physics Education in Universitas Jember, while the user validator is a physics teacher at the school where the development test was conducted. There were 18 validation indicators divided into three aspects; the accuracy aspect, the feasibility aspect, and the efficiency aspect of the instructional materials.

The accuracy aspect consisted of 4 indicators, the feasibility aspect contained 11 indicators, and the efficiency aspect comprised 3 indicators.

Below is the validation results conducted by two expert validators and one use validator:

Table 2. The Validation Result of Instructional-Based Andro-Web Comics

No.	Indicator	Score
The Accuracy Aspects of Instructional Materials		
1.	The suitability of instructional materials with learning objectives	4,67
2.	The suitability of instructional materials with student's characteristics	4,67

3.	The suitability of instructional materials with student's learning resources	4,67
4.	The suitability of instructional materials with the learning environment	4,67
Proper Aspects of Instructional Materials		
5.	The ability of teaching materials in developing students' motivation	4,67
6.	The ability of teaching materials to attract students' attention	4,33
7.	The ability of teaching materials in creating student's pleasure	4,67
8.	The ability of teaching materials for tools to understand and remember information	4,67
9.	The ability of teaching materials to repeat what is learned	4,33
10.	The ability of teaching materials as a learning stimulus	4,33
11.	The ability of teaching materials for immediate feedback	4,33
12.	The ability of teaching materials in promoting good practice	3,67
13.	The ease of teaching materials in the practice of learning	4,33
14.	Security of teaching materials for students	4,33
15.	Quality teaching materials	4,67
The Efficiency Aspects of Instructional Materials		
16.	The efficiency of teaching materials in relation to time	4,33
17.	The efficiency of teaching materials in relation to cost	4,33
18.	The efficiency of teaching materials in relation to energy	4,33

The accuracy level of instructional-based Andro-web comics appeared in the indicator 1, 2, 3, and 4. The accuracy of instructional materials was used to determine the suitability of instructional materials with learning objectives, students' characteristics, learning resources, and learning environment. The accuracy aspect of instructional materials obtained the total score around 4,67. Based on table 1, the score was in valid criteria. These results indicated that the Instructional-Based Andro-Web Comics was suitable with the learning objectives, characteristics of students especially high school students' characteristics nowadays, school learning resource, and students' learning environment.

The feasibility level of Instructional-Based Andro-Web Comics arose in the indicator 5 to

indicator 15. The feasibility aspect of the instructional materials obtained the total score around 4,39. Thus, based on table 1, the Instructional-Based Andro-Web Comics was valid. These results indicated that the Instructional-Based Andro-Web Comics could be used as learning stimulation that was able to attract students' interest and motivation, was easily and safely used as a tool to understand, remember, and repeat what has been learned,

The efficiency level of Instructional-Based Andro-Web Comics appeared in the indicator 16-18. The efficiency aspect of instructional materials achieved the score around 4,33. Thus, based on table 1, the Instructional-Based Andro-Web Comics was valid. This indicated that the Instructional-Based Andro-Web Comics was efficient in terms of time, cost, and energy both in the process of making and learning. In the creating process, it could save time, cost, and energy since it was made of paper and on applications like Photoshop CC. While in the learning process, it could save time, cost, and energy since the Instructional-Based Andro-Web Comics is accessible without time, place and cost limitation.

The ability of Instructional-Based Andro-Web Comics to improve motivation, attract students' attention, and create students' interest, obtained the score around 4,33 to 4,67. The score is similar to the research conducted by Alfiana (2012), that 89,93% of the students were motivated to learn using instructional materials in the form of comics during the learning process. Febriandika et al. (2016), also explained that the science module with comics as instructional materials could improve students' motivation and 85,47% of students interested and paid attention to the instructional materials.

The Instructional-Based Andro-Web Comics presents the friendship of 3 high school students in which they cooperate to solve their problems. This case is expected to stimulate class discussion and train students' cooperation skills resulting in livelier classroom activities. The contextual materials presented in the Andro-web comics is expected to increase students' awareness of science and inform them that the learned materials exist and are close to their life.

The validity of Instructional-Based Andro-Web Comics as a tool for students in understanding and remembering information achieved the score around 4,67 and was in the valid category. This result is in accordance with research conducted by Fatimah & Widiyatmoko, 2014; Wahab et al., 2017, which explained that students easily understand, remember and search informa-

tion contained in the comic as it presents a coherent illustration using simple language.

Joffe (2008), describes images as memorable, easily absorbed, and gives further effect to the reader by reading or viewing it over and over again. The images contained in the Instructional-Based Andro-Web Comics are observable and readable. Students could access it whenever they need the information. They could also find the desired information by clicking on the related episode/s without much effort to search.

The validity and eligibility level of instructional materials in promoting a matching exercise obtained 3,67 in which the validity level was in quite valid. Getting score around 3,67 was possible inasmuch as the Instructional-Based Andro-Web Comics must be accessed online, so, it requires a stable wireless network to run. However, it could be overcome by using mi-fi or mini wifi capable of reaching 31 devices.

Based on the validity level criteria of instructional materials, it was in the valid level with the score around 4,46. Therefore, it concludes that the developed Instructional-Based Andro-Web Comics could be used or implemented at schools.

CONCLUSION

The Instructional-Based Andro-Web Comics belonged to worthy criteria as instructional materials having the score around 4,67 on the accuracy aspect; 4,39 on the feasibility aspect; and 4,33 on the efficiency aspect. This meant that the Instructional-Based Andro-Web Comics could be implemented at schools.

A disadvantage of the Instructional-Based Andro-Web Comics is that it must be accessed online. The offline feature is not available since the developer is not a part of the NAVER WEBTOON employee. Therefore, the test of the Instructional-Based Andro-Web Comics should take place in an area full of supporting facilities such as a stable wireless network, mobile devices, and PC / Mac.

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THE DEVELOPMENT OF PHYSICS TEACHING MATERIALS BASED ON LOCAL WISDOM TO TRAIN *SARABA KAWA* CHARACTERS

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ABSTRACT

This research came up from the unavailability of the physics teaching materials containing the local wisdom of Tabalong Regency society, South Kalimantan, and the less optimal character education in the learning process. Therefore, the research and development on the physics teaching materials based on the local wisdom of Tabalong regency, South Kalimantan to train *saraba kawa* characters were conducted. The objective of this study was to produce feasible physics teaching materials integrated with the local wisdom based on the aspects of validity, practicality, effectivity, and character achievement. This research type is a research and development using ADDIE model. The subjects of the try out were 36 grade X students of MIPA in 4 SMA Negeri 2 Tanjung Tabalong Regency. The instruments used in this study were validation sheet, response questionnaire, student achievement test, and character observation sheet. The results showed that: (1) the validity of the teaching materials based on its content and appearance was in a good category, (2) the practicality of the teaching material categorized as very practical, (3) the effectiveness of the medium categorized as very practical, (4) and the achievement of *saraba kawa* characters categorized as very good. It concluded that the physics teaching materials based on the local wisdom to train *saraba kawa* characters is feasible for physics learning.

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Keywords: local wisdom, *saraba kawa*

INTRODUCTION

Education is indispensable for human life. Its basic purpose is to improve abilities, develop potentials, educate and build individual characters. This is in accordance with the national education function and objectives contained in Law no. 20 The Year 2003 Chapter II Article 3. To achieve the national educational goals, school learnings should be implemented effectively. One of the High School subjects is Physics. Physics

Learning could be done effectively if the teaching materials support the learning activities. For example, the teaching materials in the form of a learning module could help students comprehensibly master the subject. In addition, Azizahwati et al., (2015) said that one way to create an effective and conducive learning environment is to connect the physics learning to the local wisdom. This is parallel to Wahyuni (2015), who stated that local wisdom is relatable to education activities. Furthermore, local wisdom is important for students to stay close to the school and for teachers to engage with most learners (Pornpimon et

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al, 2014). According to Ratana (2016), local wisdom transmission should have a reciprocal relationship between learning networks and autonomous learning in order to play a significant role in national development. The local wisdom rooted in the students' life is contextual direct experience (Kurniawati et al., 2017). Learning based on the local wisdom is effective enough to improve students' basic competence (Suastra et al., 2011). Ethnoscience-based science learning concerning everyday life helps students grasp the learning materials (Arfianawati et al, 2016). Local wisdom contains values cultivated within a society. The value is a potential unit to develop education assessment (Toharudin & Kurniawan, 2017).

Based on the interviews conducted in SMA Negeri 2 Tanjung Tabalong regency of South Kalimantan, the physics learning took place in the school so far has not integrated learning materials with the local wisdom. Other than that, character cultivation during the learning process was less optimal. Based on the results of the analysis of physics teaching materials adopted in the school, the teaching materials have not included the potentials and local wisdom of the society in Tabalong regency.

One of the local wisdom of Tabalong community is producing brown sugar. Brown sugar is the sugar made of sap. Making brown sugar is closely related to the physics learning topic of temperature and heat. In addition, there is a well-known character of Tabalong called *saraba kawa*. According to Badan Pusat Statistik Kabupaten Tabalong (2015), *saraba kawa* is a native regional language which means struggle and determination of Tabalong people to perform their duties and obligations to the nation, state, and religion. This character is in accordance with the local wisdom of Tabalong regency in making the brown sugar which must be accompanied by hard work and desire. Therefore, it is necessary to develop physics teaching materials integrated with local wisdom to help learners gain learning experiences related to real-life activities. One of the potential developed materials is a module. Pratama et al., (2015) revealed that module development is a current ideal requirement because the competence approach presupposes the use of modules in learning activities. The use of teaching materials integrated with the local wisdom is suitable for Indonesian youth education (Meliono, 2011). In addition, Hidayanto et al., (2016) showed that the use of physics modules integrated with local wisdom could improve the learning effectiveness to improve the students' achievement. It is also supported by Oktaviana et al., (2017) who said that

the module integrated with local wisdom could help cultivate the characters to students.

Keeping this in mind, the research and development of teaching materials in the form of modules was conducted. The purpose of this study was to develop the teaching materials integrated with local wisdom to introduce the character of *saraba kawa* based on its validity, effectiveness, practicality, and character achievement. It is expected that through this research, the physics materials based on the local wisdom of South Kalimantan are feasible to contribute to physics, that is to build scientific knowledge based on local wisdom. In addition, this research was expected to be an alternative reference to improve the quality of physics learning in gaining knowledge and cultivating characters of students.

METHODS

It was a research and development using the ADDIE model comprising the steps of analysis, designing, developing, implementing, and evaluating (Rahmayanti et al., 2016). The subjects of this research were the physics learning materials of temperature and heat integrated with the local wisdom of making brown sugar for the *saraba kawa* character. The research objectives were the feasibility of physics teaching materials based on its content and appearance validity, practicality, effectiveness in cultivating students' character. The subjects of the try out were taken by using purposive sampling technique in 36 grade X students of MIPA in 4 SMA Negeri 2 Tanjung Tabalong. The instruments employed in data collection were validation sheet, response questionnaire, achievement test, and character observation sheet.

The validity of the teaching materials was measured using a validation sheet of teaching materials (Sari & Alarifin, 2016). The validation result of the teaching material was determined by the criteria in Table 1.

Table 1. The Assessment Criteria for Each Aspect of Validation of Teaching Materials

Average Score	Classification
$X > 3.40$	Very good
$2.80 < X \leq 3.40$	Good
$2.20 < X \leq 2.80$	Fair
$1.60 < X \leq 2.20$	Less good
$X \leq 1.60$	Poor

(Adopted from Widoyoko, 2016)

The practicality of the teaching materials was measured by the students' questionnaire response (Khumairah et al., 2014). The questionnaire used consisting of ease, benefit, and time efficiency aspect (Hamdunah, 2015). The criteria for teaching materials practicality are shown in Table 2.

Table 2. The Assessment Criteria for Teaching Materials Practicality

Average Score	Classification
$X > 3.40$	Very practical
$2.80 < X \leq 3.40$	Practical
$2.20 < X \leq 2.80$	Quite practical
$1.60 < X \leq 2.20$	Less practical
$X \leq 1.60$	Not practical

The effectiveness of teaching materials is seen from the level of success achieved by students after the learning process using the teaching materials (Suryani et al., 2014). The Effectiveness of the learning is measured using the student achievement test (Rahmayanti et al., 2016), from the pretest and posttest scores (Rahayu & Sudarmin, 2015). The achievement test was analyzed using the normalized gain (N-gain) equation (Hake, 1998).

$$\langle g \rangle = \frac{(\%<S_f> - \%<S_i>)}{(100 - \%<S_i>)} \quad (2)$$

The S_f and S_i was the average score of posttest and pretest classes. The effectiveness of students' learning outcomes appears in Table 3.

Table 3. The Criteria for Learning Effectiveness

No.	N-gain value	Criteria
1	$\langle g \rangle \geq 0.7$	High
2	$0.7 < \langle g \rangle \geq 0.3$	Medium
3	$\langle g \rangle < 0.3$	Low

(Hake, 1998)

The achievement of the students' character was assessed using the observation sheet (Lusia & Arief, 2013). The average score obtained from the observation sheet was adjusted to the criteria of the students' achievement on the *saraba kawa* characters is presented in Table 4.

Table 4. The Assessment Criteria Achievement of Students Character

Average Score	Classification
$X > 3.26$	Very good
$2.42 < X \leq 3.26$	Good
$1.58 < X \leq 2.42$	Fair
$0.74 < X \leq 1.58$	Less good
$X \leq 0.74$	Poor

(Widoyoko, 2016)

RESULTS AND DISCUSSION

The Developed Product

The product developed in this research is physics teaching materials integrated with local wisdom on temperature and heat material on the tenth grade at the 2013 curriculum to educate the *saraba kawa* characters. The local wisdom meant in this study was the process of brown sugar making in Tabalong regency which was associated with the temperature and heat topic as well as the characters of *saraba kawa*.

The ethnoscience approach was implemented in physics learning by incorporating culture (making brown sugar). The production process of brown sugar was discussed using physics concepts of temperature and heat. The physics teaching materials integrated with local wisdom were expected to assist the students in finding information as well as translating hereditary science about the making brown sugar in Tabalong area into scientific knowledge. As stated by Rahayu & Sudarmin (2015), the development of ethnoscience-based module is an assimilation of scientific knowledge and original knowledge.

The physics teaching materials developed in this study were in the form of modules referring to the criteria from the Department of National Education (2008) consisting of the opening, core, and closing part. The opening section included a cover, introduction, table of contents, instructions on the use of modules, core competencies, basic competencies, learning indicators, learning objectives, module description, map concepts, the introduction of local wisdom, and keywords. The core section comprised a description of the material, student worksheet, summary, competency test and its answer key. The cover section involved a glossary and a bibliography. The material description was developed into four meetings associated with the local wisdom of making the

brown sugar and *saraba kawa* characters. The student worksheets were assigned in every meeting to know the achievement of learning objectives.



Figure 1. The Development Result of Physics Materials

The Validation Results of the Physics Learning Materials

The validation of physics learning materials was divided into content validation and appearance validation. The results of the teaching material validation analysis are given in Table 5.

Table 5. The Validation Results of Material Content

Aspect of Assessment	Average	Category
Quality of Content	3.50	Very good
Organization	3.33	Good
Language	3.00	Good
Evaluation	3.00	Good
Validity	3.21	Good

The average results of the content validation of the teaching materials were 3.21 and categorized as good. The validation analysis results of the teaching materials on the appearance aspect is shown in Table 6.

Table 6. The Validation Results of Teaching Materials Appearance

Aspect of Assessment	Average	Category
Consistency	3.56	Very good
Format	3.33	Good
Appeal	3.58	Very good
Form and font	3.33	Good
Language	3.00	Good
Validity	3.36	Good

The average validation result of the teaching material appearance was 3.36 and categorized as good.

The validity is a measurement used to indicate the validity of an instrument (Arikunto, 2013). The validity of teaching materials can be done using a validation sheet (Wati et al., 2017). The validity of this study was obtained based on assessments of academic and practitioner validators. The validation results of the contents categorized as good. The content validation covered the quality aspects of content, organization, language, and evaluation. Of teaching materials, it indicated that teaching materials required minor revisions. Revisions were made based on suggestions provided by the validators. The validation results of the appearance classified as good. The appearance validation of teaching materials involved the aspects of consistency, format, attractiveness, font size, and language which categorized as good yet needed minor revisions.

Referring to Afriadi et al., (2013) the validity shows the suitability, meaningfulness, and usability of the conclusions made. Therefore, the higher the validity of the teaching materials developed the better the conclusions, the level of meaning, and its usefulness was. The teaching materials validation on the aspect of content and appearance resulted in the good category. This category indicated that the physics teaching materials integrated with the local wisdom have been made in accordance with the aspects of the content and appearance validation; therefore, it is suitable for the teaching-learning process.

The Practicality of the Physics Teaching Materials

The practicality of teaching materials was measured through a response questionnaire comprising the aspects of convenience, benefits, and efficiency. The analysis results of the teaching materials are presented in Table 7.

Table 7. The Results of Questionnaire Response Analysis

Aspect of Assessment	Average	Category
Ease of use	3.46	Very practical
Benefits	3.43	Very practical
The efficiency of learning time	3.42	Very practical
Average	3.44	Very practical

The analysis results of the teaching materials practicality were 3.44 and classified as very practical.

According to Nieveen in Rochmad (2012), the practicality level indicated that the materials were easy to be run by teachers. Referring to the analysis results, the developed physics teaching materials categorized as very practical. This showed that the teaching materials made it easy for the learners to grasp and fostered them to learn independently.

In regards to the module, it is a printed teaching material designed by teachers for students to be learned independently (Fitri et al., 2013). A module is arranged systematically and attractively covering the materials, methods, and evaluations (Tjiptiany et al., 2016). According to Prastowo (2015), a module is a teaching material arranged systematically using comprehensible language for learners in line with their level of knowledge and age. Hence they can learn independently with or without a teacher's assistance.

Local-based science (physics) learning process could encourage learners to build their knowledge and connect it to with reality/phenomena experienced by students in everyday life (Setiawan et al., 2017). This can increase students' interest (Damayanti et al., 2013), motivation (Perdana et al., 2017), enthusiasm in learning science (Atmojo, 2015) resulting in more meaningful learning (Nisa et al., 2013). The use of the teaching materials integrated with the local wisdom could provide benefits for students. The same thing is also stated by Asfiah et al., (2013), that is by using the module, it could help students comprehend the materials better.

The Effectiveness of the Physics Teaching Materials

The effectiveness of the teaching materials developed was measured through assessment of the students' learning outcomes. The analysis results of the student's achievement test are shown in Table 8.

Table 8. The Test Results Analysis of the Student Achievement

Pretest Average	Posttest Average	N-gain
2.51	66.18	0.65

The N value $\langle g \rangle$ obtained from the analysis of the students' cognitive achievement was 0.65 and categorized on the medium category. It indicated that the physics teaching materials integrated with the local wisdom were effective to improve the students' achievement and accomplish the learning objectives.

Through these physics teaching materials, the students could easily understand the discussed materials and see examples of the application of temperature and heat topic in everyday life based on the events of making the brown sugar presented through pictures and information on the module. In addition, the images and information concerning the manufacturing process of brown sugar served to motivate the students to study the developed teaching materials and the students' achievement increased so that the learning objectives were accomplished.

Modules could help realize a good quality learning (Jaya, 2012). The use of modules in the learning process requires students to learn independently (Yuliawati et al., 2013) so that learners are actively involved in the learning process. The students' activities ultimately affect the achievement (Izzati et al., 2013), thus, the learning quality would be better (Setyowati et al., 2013). In addition, the local wisdom integration in the learning process supports the science learning well (Suastra, 2010).

This is in accordance with the research results by Oktaviana et al., (2017) that the local wisdom-based physics module could improve the effectiveness of learning and students' achievement (Rahmayanti et al., 2016). Ethnoscience-based science learning guides students in finding and building their own knowledge (Rahayu & Sudarmin, 2015). Moreover, the local wisdom-based learning results in a more meaningful learning since the observed object exists in the environment (Susilawati et al., 2016).

Cultivating Characters to the Students through Physics Teaching Materials

The characters trained in the developed physics teaching materials were the characters of *saraba kawa*. The achievement indicators were tenacity in encountering the problems during the learning process, ability to solve the problem by finding the right solution, and ability to do the task carefully and timelines in completing the tasks. The average achievement for each meeting can be seen in Table 9.

Table 9. The Achievement Results of the Learners' Characters

Character	Meeting	Average	Category
<i>Saraba kawa/</i> Hard Work	I.	3.25	Good
	II	3.31	Very good
	III	3.25	Good
	IV	3.36	Very good
Overall Average		3.29	Very good

The achievement analysis result of *saraba kawa* character was 3.29 classified as very good. Based on the achievement analysis of the *saraba kawa* character, it indicated that the students finished the task carefully and neatly, did not give up in facing the problems, made use of the time effectively, and were capable of solving the problems by looking for the right solution. This showed that the use of the physics teaching materials integrated with local wisdom in Tabalong regency could help students practice *saraba kawa* characters.

The physics learning integrated with local wisdom created a harmony between the knowledge and cultivated attitudes for the values growth in society. The development was accomplished through several stages of exploration, focusing, investigation of various perspective, elaboration, and confirmation (Suastra & Yasmini, 2013). The local wisdom-based learning is able to grow students' character (Khusniati, 2014). This is in accordance with the results done by Hartini et al., (2017) which found that the use of local wisdom-based physics materials could assist teachers to educate characters related to the local wisdom. This is parallel to Mardiansyah et al., (2013), who revealed that effective teaching materials not only made students understand the subject but also flourish in values and characters.

CONCLUSION

Based on the development and testing result, it concluded that the physics teaching materials integrated with the local wisdom to cultivate *saraba kawa* were feasible to use. This was supported by the data collected during the study, namely the teaching materials validity from both aspects of content and appearance which classified as good, the practicality which categorized as very practical, the effectiveness of the teaching materials which included in the medium category, and the accomplishment of *saraba kawa* characters which was in very good category.

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THE INFLUENCE OF INQUIRY-BASED SCIENCE ISSUES LEARNING ON PRACTICAL SKILLS OF JUNIOR HIGH SCHOOL STUDENTS IN ENVIRONMENTAL POLLUTION TOPIC

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ABSTRACT

Inquiry-based science issue approach facilitates the development of scientific skills through research activities on surrounding science issues. The purpose of this research was to understand the influence of Inquiry-based science issues on practical skills of Junior High School students. This research employed quasi-experimental research method, equipped with pre-test, post-test non-equivalent control group design. The sample of sixty junior high school students in Yogyakarta was picked for this study. The instruments used were observation sheets on practical skills, practical skills test, and instructional learning sheets. The data collected were analyzed using N-Gain, percentage, and Analysis of Covariate (ANCOVA) at 0.05 significance level. The result revealed that Inquiry Science Issues was more effective in fostering students' practical skills than the scientific approach. There was a significant effect of treatment on students' practical skills while no interaction between approach and prior knowledge of students. Moreover, the data of practical skills through the observation sheets in the experimental class had higher percentage compared to the control class, 80.36%, and 70.61% respectively.

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Keywords: influence, inquiry-based science issue, practical skill

INTRODUCTION

Nature of Science (NOS) is an important element in the implementation of science learning. This element should be understood by either teachers or students. The understanding of NOS is very important to develop some aspects of science that help students comprehend science well including content understanding, scientific work, positive characters, and scientific attitude (Faikhamta, 2013). It is further explained that studying Science would provide three kinds of science skills and understanding for students: science principles, science concepts, reasoning

skills and performing scientific procedures, and understanding the nature of science as a specific form of human effort (National Research Council, 2000).

Science is a process of studying the universe. The process is done through scientific activities in the form of data collection through observation and inference through investigation (Lederman et al., 2014). The data collection is followed by a theory review which is then adopted to explain the observed or investigated phenomena. Thus, teaching science as its essence is a way of investigating which of the approach facilitates students to practice as well as cultivate the required skills to conduct investigations (Demirdö et al., 2016). Science learning involving students in

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inquiry activities by integrating skills, knowledge, and attitudes would help students to understand the concepts of Science (Zeidan & Jayosi, 2014; Gormally et al., 2009). Students would process messages to gain knowledge, skills, and values of Science through Inquiry (Setiawan et al., 2016).

Inquiry learning could give students the opportunity to apply the procedures used by scientists to identify problems, ask questions, present research steps, provide persistent explanations, make predictions, and arrange explanations that support the experience (Ambarsari et al., 2013). The inquiry is one of the investigation-based approaches, which is a way to ask questions and look for a proof of a problem to find accurate information. Inquiry-based learning will help students to develop rational ways of thinking, critical thinking and scientific skills, and scientific literacy (Villardón-gallego, 2016). In addition, inquiry learning does not only encourage the ability to think but also the ability to work and communicate scientifically (Savitri et al., 2017). According to the National Research Council (2000), scientific literacy is the ability to understand scientific concepts and processes that are essential for making decisions related to personal as well as social issues. To solve problems or issues, teachers need to involve students in investigating the problems during a science lesson. Inquiry-based learning will improve students' problem-solving skills resulting in students' development of high-level thinking skills, discussion skills, investigation, and understanding of science facts (Cahyarini & Rahayu, 2016).

Investigations are brought to Science class through Inquiry-based science issues approach. The inquiry-based learning facilitates students to solve it through investigation, resulting in the development of their thinking and reasoning skill (Pratiwi et al., 2016). The characteristics of Inquiry-based science issues learning can be seen from the students' orientation of raising scientific questions concerning a certain issue. The students then formulate problems, state hypothesis, gain proofs, test the hypothesis, and conclude the result to answer the determined questions.

Previous research found that in learning science process struggles with the cognitive aspect without considering the skills aspect. The facts found that students have not been able to select the tools used in the experiment correctly; in addition, they have not been able to perform the procedure well and have not communicated the image data or graphics, not exactly in making in-

terpretation of experimental results. Meanwhile, those skills are indispensable for the achievement of practical skills that are part of the skill aspect in the science learning outcomes. The approach of inquiry-based science issues is expected to help students grow their practical skills since they conduct investigations through practicum activities. Practical skills in science learning are related to the skills possessed by the students to be able to discover the concept of science through observation, experiment, or investigation. Abraham (2012) stated that practical skills are skills that can increase students' competence in performing various scientific activities involving the activity of manipulating variables and observing the real objects. The four categories of practical skills include procedural and manipulative skills such as planning investigations, and selecting the right tools and materials while safety comes first. Observational skills are related to appropriate observations and measurements while drawing skills deal with the process of organizing data through tables and graphs, drawing the tools, sketching, and giving a description of the image. Moreover, reporting and interpretative skills include the process of recording, interpreting and reporting results accurately.

During the investigation, students can practice using tools and materials, and follow the procedures with safety concerns. Students can practice observing, gathering information, and performing accurate measurements using relevant tools and appropriate units. After obtaining the data, students can practice determining the appropriate method to organize the data of the investigation that has been put in tables or graphs (Zafra-gómez et al., 2015). Through the inquiry process, the students also contribute their ability to analyze and interpret the results of their investigation by identifying patterns and relationships appeared in the data. Through instruction with Inquiry science issues approach, students will conduct an inquiry to solve problems through practicum activities, where this activity will bring up the students practical skills. Thus, the four categories of practical skills can be applied and developed through the process of inquiry learning. Therefore, the purpose of this research is to investigate whether or not there is any influence of the application of Inquiry-based science issues on Practical Skills of Junior High School students in Environmental Pollution topic, which is a familiar and factual one.

METHODS

This research used quasi-experimental design. The adopted research design was non-equivalent control group design. This design used in consideration that intact classes seems impossible to have completely randomized the subject (McBurney et al., 2010). The study conducted in SMP 1 Paliyan Yogyakarta in the even semester, the academic year of 2016/2017 in April 2017. The population in this study was all students of grade VII, SMP N 1 Paliyan. One class took as an experimental class and the other as a control class. The experimental class was a class taught with the Inquiry-based science issues approach, while the control class was taught with the Scientific Approach. The instruments employed in this research including learning activity observation sheets, practical skill observation sheets, and questions on pretest-posttest of practical skills that have been examined empirically to find out its validity and reliability. The questions have been declared valid, with high reliability of $r_{11} = 0,69$.

Data were analyzed using N-Gain, percentage while inferential statistic such as Analysis of Covariate (ANCOVA) was used using pretest scores as a covariate to test the hypothesis at 0.05 significance level (Çetin, 2013). The hypotheses proposed in this study are:

H_0 : There is no influence of Inquiry-based science issues on practical skills of the Junior High School students.

H_a : There is an influence of Inquiry-based science issues on practical skills of the Junior High School students.

RESULTS AND DISCUSSION

In this research, a hypothesis test was carried out to know whether or not there was an influence of Inquiry-based science issues on practical skills of the Junior High School students at SMP 1 Paliyan. The control class applied

the scientific approach and experimental class adopted the inquiry-based science issues approach. During the learning process, the researchers observed the implementation of both approaches at both classes.

The observation sheets were used to observe the learning process and came up with these three activities as presented in Table 1.

Table 1. Percentage of Learning Performance

	Activity 1	Activity 2	Activity 3
Experimental class (<i>inquiry-based science issue</i>)	100%	100%	100%
Control class (<i>Scientific approach</i>)	98%	98%	100%

Based on the observation results obtained from both classes, the average was 100%. The value indicated that all teachers' activities and students' activities had been done successfully. The lessons were designed to foster the students' practical skills. The approach of inquiry-based science issues refers to a learning process that exposes the students to science issues on environmental pollution topic and facilitates students to solve them through investigation (Zion & Mendelovici, 2012). This is parallel with the research by Dewi & Prasetyo (2016) who found that this approach successfully improves students' practical skill to solve problems. There are six inquiry learning stages; problem orientation, formulating problems, formulating hypotheses, gathering evidence, testing hypotheses, and making a conclusion (Simsek & Kabapinar, 2010). In this study, the orientation focused on science issues. Therefore, the first stage was the orientation on science issues, formulating problems, formulating hypotheses, gathering evidence, testing hypotheses, and forming a conclusion, as presented in Table 2 based on the result.

Table 2. The Learning Stages of *Inquiry-based Science Issues*

Inquiry stages	Teachers' Role	Students' Role
Orientation on Science issues	Giving reading sources containing science issues adapted to the topics and learning objectives.	Taking a close look at the science issues presented.
Formulation questions	Asking the students to discuss and identify conflicts arose on the issues.	Discussing to identify the emerging conflicts on science issues.
Formulating hypotheses	Based on the observed issues, the teacher guided the students in raising questions based on the issues presented.	Formulating questions based on the explored issues.

Gathering evidence	Guiding the students in formulating simple hypotheses based on the examined questions by encouraging the students to have discussions with their friends	Collecting relevant information related to the examined questions to formulate hypotheses.
Testing hypotheses	Helping and guiding groups in performing tasks and organizing the data.	Formulating simple hypotheses.
Making a conclusion	Supporting and giving the students opportunity to have discussions in finding the relation and pattern of the obtained data	Understanding the work procedures.

The inquiry-based science issues approach puts teachers as problem providers. Furthermore, Llewellyn (2011) stated that in addition to determining problems or questions, teachers should provide advice on what tools and materials should be used while encouraging students to design safe work procedures to solve problems. The students then carry out the work procedures, obtain data, and formulate explanations and conclusions from the data obtained. During the lesson, the teachers act as a facilitator who monitors the students and guides them when they need. The teachers' role is as a facilitator ensuring the students have no difficulties in performing activities. Guidance is given in the form of questions instead of direction about what students should do. Through questions, the teachers assist the students in solving questions or problems as well as provide assistance in formulating explanations for the investigation results (Demirdö, 2016). Practical skills emphasized in every activity have four categories, which are (1) procedural and manipulative, (2) observational, (3) drawing, and (4) reporting and interpretative. Those are expected to appear in each activity (Kumar, 2009). The data of practical skills were collected using observation sheets presented in Table 3.

Table 3. The Achievement Data of Practical skills through the Observation Sheets.

Practical Skills Aspects	Experiment Class (%)	Control Class (%)
Procedural and manipulative skill	79.32	69.25
Observational skill	86.82	75.84
Drawing skill	77.99	69.32
Reporting and interpretative skill	77.33	68.82
Average	80.36	70.81
Category	Very Good	Good

The results of observation sheet analysis show that after the inquiry-based science issues approach applied, the experiment class students' mastery of practical skills was better than the control class and the highest component in both classes was the observational skill aspect. The data of practical skills taken using test are presented in Table 4.

Table 4. The Data of Practical Skills through Test

	Average Score		N-Gain score	Category
	Pre-test	Post-test		
Experiment class	60.25	84.25	0.6	high
Control class	60.07	75.74	0.4	moderate

As seen in Table 4, experiment class had a high category in N-Gain score, means that the achievement of practical skill was better than the control class which applied Inquiry Science Issues. Students could solve the problem of science issues by investigating while they developed each aspect of practical skills. Inquiry Science Issues was more effective in fostering students' practical skills than the scientific approach.

As a prerequisite hypotheses test, normality and homogeneity tests indicated normally and homogeneously distributed data. The result of normality data was sig (2 tailed) 0.94, $p > 0.05$, while homogeneity data was sig (2 tailed) 0.333, $p > 0.025$, means that the posttest data in the experiment class were normal and homogeneity invariance. Therefore, a parametric test was conducted to test the hypotheses as presented in Table 5.

Table 5. The Results of *Analysis of Covariance*

Source	df	F	Sig
Corrected Model	2	10,629	.000
Pre-test practical skills	1	7,096	.010
<i>Inquiry-based science issues</i> Approach	1	14,162	.000
<i>Corrected Total</i>		59	
R Squared = .272 (Adjusted R Squared = .246)			

The above analysis shows that the significant number of the approach was 0,000 in which the value was less than 0.05, therefore, the H_0 was rejected. Thus, it concludes that there was an influence of Inquiry-based science issues approach on practical skills. Its influence could be simultaneously observed from the significance of the Corrected Model, having the sig value 0.000 < 0.05, thus, the H_0 was rejected. Therefore, it concludes that the Inquiry-based science issues approach influenced practical skills simultaneously. It infers that the practical skill aspect was related to the inquiry-based science issues in learning. The stage of gathering evidence facilitated the students to practice procedural and manipulative, observational and drawing skills. The stage of testing hypotheses helped the students practice reporting, interpreting, and drawing skills. In addition, the stage of formulating conclusions facilitated the students to practice reporting and interpreting skills.

An inquiry science issues learning helps students to actively involve in learning and practicing practical skills directly through investigations. The inquiry science issue learning includes the students' active roles in developing their understanding of the topics learned and developing practical skills. Moreover, the inquiry-based learning would improve the thinking skills by investigating problems or issues (Duran & Dökme, 2016). The students collect evidence and use it to explain the phenomena they are studying. In addition to building an understanding of the studied topics, students also have the opportunity to practice skills and cultivate their attitudes (Erdogan, 2017).

The category of practical skills in the form of procedural and manipulative skills trained through the stage of collecting evidence. Before collecting the data, the students have to look at the work procedures, make a selection of tools and materials, and learn to use them. This is in line with Llewellyn (2011) who explained that before the students undertake an inquiry process, they need to gather the required tools and materials, then read and follow the work procedures.

The data collection stage in inquiry-based science issues learning provides students the opportunity to gather the tools and materials needed for the data collection process. The students could also practice using the tools appropriately for their usefulness. Moreover, they would practice choosing the tools by observing its condition so that the selected tools are not disabled or even harmful. Through this stage, they would rehearse to conduct an investigation according to the ap-

propriate steps. In addition, they are also directed to always pay attention to the stay safe in working with chemicals (Abrahams & Millar, 2008.)

The above activities gave an opportunity for students to learn to choose the tools and use it according to its purpose. Busaidi & Lock (2017) stated that the students practice to assemble tools according to work procedures and release them carefully and are facilitated to learn how to operate the practicum tools. Furthermore, they are trained to always pay attention to safe work procedures in conducting an investigation. This means that they have the opportunity to continue to practice their practical skill aspect in the form of procedural and manipulative skill.

Millar (2010) stated that research confirms that students are better at using equipment and carrying out practical procedures if they had opportunities to practice doing these, rather than just being shown how to do them. This is in line with the research result indicating that the procedural and manipulative skill category emphasizing on the tool operation and the implementation of safe work procedures developed well after the students were given the opportunity to practice directly and continue to practice through inquiry-based science issues learning.

One of the practical skill aspects, the observational skill, was assigned through the stages of collecting evidence on inquiry-based science issues learning. The students required to collect data appropriately. This is in accordance with the statement of Llewellyn (2011) that during an investigation process, students need to collect data appropriately. In addition to obtaining data through observation, communicating the observational data, working procedures, and analysis results are the important parts of the scientific process (Bass et al., 2009). Therefore, skills in making tables, diagrams, graphs, and sketches become an important thing in communicating the obtained results.

Skills in creating tables, picture series, graphs, sketches, and diagrams honed through the stages of collecting evidence on inquiry-based science issues learning. After obtaining the observational data, students must organize the data into tables and diagrams. This means that the students have the opportunity to continue to rehearse practical skills in the form of drawing skill. Harlen (2014) revealed that the most important way to develop skills in communicating data in the form of images, tables, graphs, or diagrams is to provide ideas about how to record certain kind of information using tables, drawings with labels and symbols.

The fourth aspect of practical skills is reporting and interpreting skill. This includes skills in recording observations according to the data obtained, classifying and interpreting observations, and making appropriate conclusions. Skill in recording observations is required while collecting evidence. The stage of collecting evidence in inquiry-based science issues learning involves the students' active roles in collecting tools and materials, observing, collecting data, and recording observations. The teacher ensures that the students record their observations and guide them to record the observations according to the facts found. Time allotment for the students to record observations is also important. This is parallel with Bass et al. (2009) that during the activity, providing sufficient time for the students to record their findings is really essential. Therefore, by using inquiry science issues, students could improve their practical skills by doing experiments to solve problems especially science issues

CONCLUSION

The process of learning science is still struggling with the cognitive aspect without considering the skills aspect. The approach of inquiry-based science issues is expected to help students grow their skills aspect in particular practical skills since they conduct investigations through practicum activities. Practical skills in science learning are related to the skills possessed by the students to be able to discover the concept of science through observation, experiment, or investigation. The inquiry-based science issues approach puts teachers as problem providers by involving science issues. The learning stages of inquiry-based science issues include six stages: orientation to science issues, formulating problems, formulating hypotheses, gathering evidence, testing hypotheses, and concluding. Besides, the data of practical skills on the observation sheets derived from the experimental class had a higher percentage than control class on Procedural and Manipulative skill, Observational skill, Drawing skill, Reporting and interpretative skill, compared to the control class'. The results of hypotheses testing were significance (0,000) <0.05 which means that there was a significant influence of inquiry-based science issues learning on practical skills of Junior High School students in Environmental Pollution topic. The result revealed that Inquiry Science Issues was more effective in fostering students' practical skills than the scientific approach. There was a significant effect

of treatment on students' practical skills while no interaction between approach and prior knowledge of students.

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STUDENTS' MENTAL MODELS OF ACID AND BASE CONCEPTS TAUGHT USING THE COGNITIVE APPRENTICESHIP LEARNING MODEL

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ABSTRACT

A mental model is a student's perception or description of a concept. Chemistry learning requires deep understanding which includes three levels of representation; macroscopic, sub-microscopic, and symbolic. These three levels of representation are interconnected to form a meaningful understanding and students' mental models. The purpose of this study was to look at the mental models of students on acid and base topic that was taught using the cognitive apprenticeship learning model. This research employed explanatory sequential mix method with 65 research subjects. The research instrument was in the form of a description and an interview guide. The results showed that the students' mental models were divided into three types; scientific, synthetic, and initial.

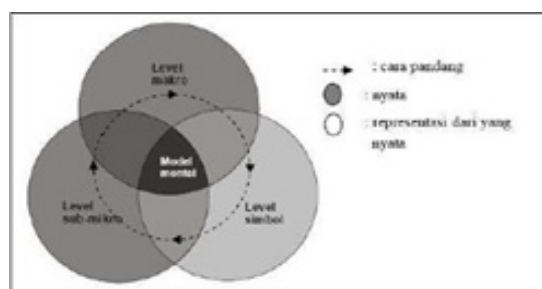
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Keywords: mental model, cognitive apprenticeship, acid and base

INTRODUCTION

Chemistry learning requires understanding at three levels of representation, namely macroscopic, submicroscopic, and symbolic (Chandrasegaran et al., 2008; Davidowitz et al., 2010; Jurišević et al., 2008). In order to understand the chemistry concepts correctly, students must be able to understand the three representations. Chemistry learning should start from the macroscopic and symbolic and proceed to the submicroscopic aspect since such aspects are the most difficult to comprehend aspects (Cheng, 2009). A student's understanding on the macroscopic and symbolic aspects is directly identifiable, but the understanding at the sub-microscopy level is observable if the student's mental model is recognized. Devetak, et al. (2009) revealed the relationship between mental models and the three le-

vels of representation. The relationship between students' mental models and the three levels of representation appears in Figure 1.



Source: Devetak, et al. (2009)

Figure 1. The Relationship of Mental Models and the Three Levels of Chemistry Representation.

Johnson-Laird in Johnson-Laird (2013) stated that a mental model is a description of what the student thinks of a particular situation that can be seen in his/her way of delivering

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reasons and explanation. Gentner & Stevens (2014) also revealed that the mental model is a person's representation in understanding and explaining a phenomenon. The mental model is also used to support a person's understanding and logic explanation of a certain condition and formed spontaneously when dealing with a particular situation, but the mental model can also be stored as long-term memory (Gentner & Stevens, 2014). Students' mental models are formed when they learn new concepts and make connections between information received, either in the form of texts or images (Wang & Barrow, 2011). The same thing was expressed by Stains & Sevia (2015) that mental models can be formed when a person is facing a particular problem. (Gentner & Stevens, 2014). revealed that mental models are shaped due to a certain process and repeated certain conditions. This suggests that the mental model may vary according to students' experiences and understanding.

Students' mental models are important to be identified by teachers since it could help them know how the students understand a concept, whether or not there is a mistake in their understanding. This is in accordance with Tumay's statement (2014), by knowing the students' mental models, a misconception is diagnosed. Mental models can be identified through interviews or written tests and expressed through writing, verbal explanations, and drawings (Stains & Sevia, 2015). Several studies on mental models on learning chemistry have been done before (Strickland et al., 2010; McClary & Talanquer, 2011; Wang & Barrow, 2011; Hegarty et al., 2013). Wang & Barrow (2011) found three levels of students' mental models namely high, medium, and low. The low mental model is influenced by a lack of understanding at the submicroscopic level. Referring to Gentner & Stevens, (2014), mental models can be shaped through explanation and understanding of submicroscopic level. This is related to the learning process experienced by students.

The learning process is influenced by several factors like teachers, learning resources, and learning models. The low mental model is due to the traditional learning model which less emphasizes on the submicroscopic level (Sevia & Talanquer, 2014). In line with this, Talanquer (2011) said that traditional learning refers much to the macroscopic and symbolic levels. Yet to form a proper mental model, it requires a thorough understanding of the three levels of representation. Therefore, a learning model that emphasizes the three levels of representation (Hilton & Nichols, 2011; Yakmaci-Guzel & Adadan, 2013) is ne-

cessary. The syntax in cognitive apprenticeship consists of modeling, coaching, scaffolding, articulation, reflection, and exploration. Through the syntaxes, Chemistry materials covering understanding at three levels of representation will be easier for students to accept.

One of the Chemistry topics at High School that requires an understanding of the three levels of representation is the acid and base. Many previous studies have been done and found that there are still many misconceptions occurred in acid and base concepts particularly about the concept of pH and pOH (Kala, et al., 2013). McClary & Talanquer (2011) have also undertaken a study of the acid and base mental models related to the causes of misconceptions. This study identified the students' mental models on acid and base materials taught using cognitive apprenticeship learning model.

METHODS

The samples used in this study were 65 students of grade XI IPA who were studying at MAN 1 Malang. The samples were picked using the cluster random sampling. There were ten questions validated by three validators. After that, 60 students were directed to work on the instruments as the results were analyzed in SPSS 25 for Windows. The results showed that there were two questions that must be elimination. The researchers discussed the instruments with the chemistry teacher and finally obtained four questions covering all the acid and base concepts to identify the students' mental models. The interview guidelines were employed in this study to get more information from the students. Here are the examples of the problems used as the research instruments: (1) Which of the followings have bigger acid rate; the same concentration of HCl and H₂SO₄? Explain and describe its microscopic state if both acids are dissolved in water; and (2) A strong base is diluted by adding a number of aquades. Which one is the stronger base, before or after dilution?

The students were taught the acid and base topic using the cognitive apprenticeship learning model by the researchers. The learning design and worksheets adopted have been validated by the experts, hence, it was appropriately applied in the learning process. During the learning process, some researchers conducted a question and answer randomly to some students related to the concepts studied. The final exam was performed by assigning a description test. The students' answers on the test were analyzed and categorized

based on each concept. The last stage was the interview, conducted with several students who included in the mental models' category of scientific, synthetic, and initial (Kurnaz & Eksi, 2015).

Table 1. The Evaluation Rubric for Descriptive Responses

Level of Understanding (LU)	Score	Criteria
Seemingly Understand (SU)	4	The responses contain all components of the scientifically accepted response
Partially Understand (PU)	3	The responses include some components of the scientifically accepted response
Partially Understand with Alternative Conception (PU-AC)	2	The responses show understood concept yet cover alternative conceptions
Alternative Conception (AC)	1	Scientifically incorrect responses containing illogical or incorrect information
No Understanding (NU)	0	Blank, irrelevant, or unclear responses

Table 2. The Evaluation Rubric for Visual Responses

Level of Understanding (LU)	Score	Criteria
Correct Depiction (CD)	4	The drawings reflect all components of the scientific depiction
Partially Correct Depiction (PCD)	3	The drawings reflect some components of the scientific depiction
Correct Drawings yet reflects Nonscientific Depiction (CD-ND)	2	The drawings reflect scientific or partial scientific yet nonscientific depiction
Incorrect Depiction (ID)	1	The drawings reflect wholly nonscientific depiction
No Depiction (ND)	0	Blank

Table 3. The Evaluation Rubric of Mental Models

Model of Understanding	Content	Level of Understanding
Scientific	The perceptions coincide with scientific knowledge: the answers are at level 3 (PU or PCD) or 4 (SU or CD)	$\begin{bmatrix} 3 & 3 & 3 \\ 3 & 3 & 3 \end{bmatrix}$
Synthetic	The perceptions partially coincide or do not coincide with scientific knowledge.	[All Other Possibilities]
Initial	The perceptions do not coincide with scientific knowledge: the answers are at level 0 (NU or ND), 1 (AC or ID) or 2 (PU-AC or CD-ND)	$\begin{bmatrix} 0 & 0 & 0 \\ 1 & 1 & 1 \\ 2 & 2 & 2 \end{bmatrix}$

RESULTS AND DISCUSSION

The obtained results were in the form of students' answers on the test questions and interview results. Next, the researchers chose 12 students to interview with. The results showed that the students had three categories of mental models. These categories adopted from Kurnaz & Eksi (2015).

The questions assigned to the students contained four concepts. There were acid and base ionization in water, pH of acid and base, neutralization, and dilution reaction. There were three mental models for each concept. In the acid and base ionization concept, the highest mental model category was scientific (85.3%). In this concept, the students could understand that acid and base is ionize in water, also, they could draw the visual aspect of the ionization. However, only 14.7% of the students achieved the synthetic mental models and there was no student reached the initial mental models.

The next concept was the pH of acid and base. The results indicated that only 55.4% of the macquired scientific mental models. 39.4% of the students reached the synthetic mental models and 5.2% of the students arrived at the initial mental models. For the other concepts, there were only a small percentage of scientific mental models. This indicated that concept requiring complex

understanding made the students difficult to elucidate it using scientific explanation. As a result, they spent much effort to draw the sub-microscopic aspect.

The following is an example of the students' answers to one of the questions and interviews, having three students for each category.

Example:

A student measures the pH of two acid solutions, namely hydrochloric acid and sulfuric acid. Both have the same concentration that is 0.01 M. Which solution has greater acid rate? Explain and describe its microscopic state if both acids are dissolved in water

Student A

Sulfuric acid has a greater acid rate than hydrochloric acid because its number of H^+ ions is bigger than hydrochloric acid's.

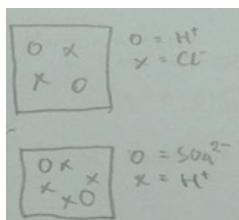
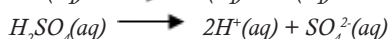


Figure 2. The Student A's Answer

Researchers: What do you mean by having a higher number of H^+ ions on H_2SO_4 (compared to HCl) when the concentration is the same?

Student A: The number of H^+ ions can be seen by multiplying the concentration with the H^+ ion coefficient based on the ionisation reaction.

Researchers: Why a stronger acid is an acid having more H^+ ?

Student A: The more H^+ means the higher the H^+ concentration and the OH^- ion concentration decrease. That means the pH is getting smaller. For the acid, the smaller the pH, the greater the strength.

Researcher: It is dissolved in water, isn't it? Does it all turn into ions? Are there the water molecules?

Student A: yes, HCl and H_2SO_4 are strong acid. So it's all ion. There is water, but it's not drawn.

Researcher: In the drawing of H_2SO_4 it's SO_4^{2-} , depicted by 1 symbol. What does SO_4^{2-} look like, actually?

Student A: That's just a picture, there's actually an S atom binding to the O.

The student A belonged to scientific mental models because s/he explained why H_2SO_4 is stronger than HCl . Student A also understood that the larger the H^+ ion, the acid gets stronger and the pH becomes smaller. The number of H^+ in H_2SO_4 is also larger and accurately described, though symbolically, instead of real H^+ and SO_4^{2-} images.

Student B

Sulphuric acid is stronger. The coefficient of H^+ is 2, whereas HCl is only 1. Based on the prior experiment, the pH of HCl is higher than H_2SO_4 .

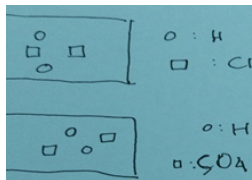
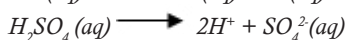
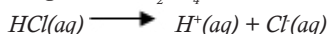


Figure 3. The Student B's Answer

Researchers: The coefficient of H^+ is higher on sulfuric acid.

Why do you describe it as high as HCl 's?

Student B: That's just a picture. The number is the same as the SO_4 and is not compared to HCl .

Researchers: Do you mean H and Cl , or H^+ and Cl^- ion?

Student B: There are $+$ and $-$ charge.

Researchers: Are you saying that the comparison between H^+ and SO_4^{2-} ions is the same?

Student B: Yes, it is the same.

Researchers: You drew it as boxes, does the SO_4^{2-} atom look like that?

Student B: Yes, it does.

Researchers: Are you sure that sulfuric acid is stronger than HCl ?

Student B: I am. It has higher H^+ . Its pH was also smaller.

The student B was classified to the synthetic mental models since the s/he was able to write the ionization reaction appropriately and understood if the larger H^+ leads to greater acid rate. However, s/he has not been able to present a microscopic picture of the ionization result of sulphuric acid. S/he thought that the ratio of $+$ and $-$ ions is always the same without considering the coefficients.

Student C

HCl is a stronger acid than H_2SO_4 because of its higher pH.

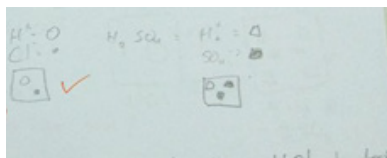


Figure 4. The Student C's Answer

Research: How do you come up with that picture?

Student C: Because they are ionized and turns H_2^+ and SO_4^{2-} . 1 to H and 2 SO_4 .

Researcher: Is there any water in it?

Student C: No, it's all acid.

Researchers: Why is sulphuric acid stronger?

Student C: Its pH is smaller than HCl .

Researcher: If the pH is smaller, is the H^+ higher?

Student C: No, it's smaller.

Student C included in the initial mental models since s/he did not describe the ionization

reaction and assumed that the H_2SO_4 ionization results were H_2^+ and SO_4^{2-} . S/he also assumed that at the terion, the number corresponds to the charge. Thus, H's charge was +1, the sum was 1, whereas SO_4^{2-} 's charge was -2, so the ionizing number was 2. Student C was also less understood if there was water in the acid, but it was not described. The phase (aq) should have indicated that there was aquades in the reaction.

Based on the result of interview, it concluded that the students with a high score on test obtained a good understanding in three levels representation. Thus, the students having good mental models were be better on concept understanding. It is similar with last study which stated that mental models have relation with concept understanding (Devetak, 2009).

CONCLUSION

Based on the results, it concluded that most of students achieved scientific mental models in acid and base ionization, and about 50% of them had scientific mental models in other concepts. Cognitive apprenticeship learning model could be considered appropriate in a learning that requires understanding at three levels of representation, since it has syntax modelings in which the teachers could strengthen students' understanding at sub-microscopic level. In addition to the last syntax, there was the exploration stage, resulting in the students' better understanding in new and more complex problems.

Future research on mental models is required since identifying students' mental model is essential for teachers to know the students' level of understanding, difficulty, and misconception. The cognitive apprenticeship learning model on Chemistry concepts also needs further investigation, inasmuch as there are not many prior research investigating such learning model. Further research is expected to award beneficial contribution to the education world.

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**METACOGNITIVE SKILL PROFILES OF CHEMISTRY EDUCATION STUDENTS IN SOLVING PROBLEM AT LOW ABILITY LEVEL****Ijirana*¹ and Supriadi²**^{1,2}Universitas Tadulako, Kampus Bumi Tadulako
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Accepted: March 17th, 2018. Approved: May 29th, 2018. Published: June 30th, 2018**ABSTRACT**

The objective of this study was to categorize and describe the behavior of chemistry education students' metacognitive skills who had a low chemical understanding (low ability) in solving problems. The findings would be the basis of data for the development of instructional design on chemistry topics by utilizing metacognitive skill aspects. The subject of this study was two first-year students of chemical education, academic year 2016/2017 that joined a basic chemistry course at the low-level ability in Universitas Tadulako. Two subjects were picked through networking using a valid test comprehension. The subjects were determined regarding the percentage of low ability which was 87% of 79 students. The profile data of metacognitive skill were obtained through an essay test, think aloud and interview. The earned data were reviewed, grouped, encoded, and examined to see its credibility employing the method and time triangulation. The research found that both students of chemistry education having a low-level of basic chemistry adopted planning skills in solving problems which were the problem identifying, goal determining, and strategy managing. However, both did not use monitoring and evaluating skills.

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Keywords: low level ability, metacognitive skills profile, problem-solving

INTRODUCTION

Chemistry is a discipline with the major purpose is obtaining an organized bunch of knowledge and skills in solving a problem. The problem-solving skills could be achieved if the solver has relevant knowledge and principles in mind (Cooper & Sandi-Urena, 2009). Therefore, problem-solving skills are influenced by students' understanding of materials dealing with problems and thinking process as a mental activity done by students to find solutions. Several researchers such as Dinsmore et al. (2008); Gauchon & Méheut, (2007); Levy Nahum et al. (2004); Bello et al. (2007); Bilgin et al. (2009) and Bunce (1993) stated that many students find it difficult in understanding and applying chemistry concepts. This is in line with the data reported by Cracolice et al. (2008), which showed students' ave-

rage scores in problem-solving skills on Stoichiometry, Molarity, Density, and Ideal Gas were 9,8%; 22,5%; 41,1%; dan 42,9% respectively. In addition, a research conducted by Ijirana et al. (2013) showed that first-year chemistry students of Universitas Tadulako had an incomplete problem-solving structure of knowledge. This indicated that a lot of students faced difficulties in comprehending chemistry concepts and had low ability level in solving problems. They had some difficulties to perform the problem-solving skills such as compiling, monitoring and checking his/her thinking process when solving a problem.

One's knowledge to control his/her ability in arranging, monitoring, and re-examining his/her understanding and action in solving a problem are closely related to metacognitive skills. These skills are part of knowledge dimension, other than the factual, conceptual, and procedural knowledge that learners must possess (Anderson

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et al., 2001). Students having metacognitive skill indicate their ability to think about ideas explicitly and understand chemistry concepts well (Rompayom et al., 2010; Uzuntiryaki-Kondakci & Capa-Aydin, 2013). Cooper & Sandi-Urena (2009) said that metacognitive skills could help students understand chemistry well and improve their problem-solving skills. Moreover, Metali-dou (2009) revealed that metacognitive skill refers to students' ability to plan the accomplishment of the objectives and the way of managing, monitoring, and modifying the problem-solving process. Therefore, a study of metacognitive skills in problem-solving process is important. The skills that need to be studied include planning, monitoring, and evaluating.

Students' metacognitive skill profiles indicate descriptions of chemistry students and difficulties they have that owe to their failure in solving problems. Those descriptions could be in the form of thinking level, understanding level on main materials of the problems, and concepts or other knowledge they need in order to solve problems. Therefore, knowing students' metacognitive skill profiles will facilitate lecturers to determine learning methods or strategies that should be applied to decrease students' difficulties. Thus, it is an urge to examine whether having students' metacognitive skill profiles could contribute to education world or not.

With this in mind, the researchers wished to find out forms of students' metacognitive skills based on the students' understanding as a mental activity in solving chemistry problems. The description was employed by lecturers to anticipate phenomena found in their classes, particularly when students solved problems as a manifestation of chemistry learning's purpose.

METHODS

This study was a basic research and used a qualitative descriptive method (Creswell, 2014). To obtain the research subject, a selection was conducted for students who attended the basic chemistry course in their second year of college, the academic year 2016/2017, chemistry education major in Universitas Tadulako. There were 79 students in the class of 2016/2017 who joined the grading test. The comprehension levels were divided into 3; high, medium, and low. The problems given on the grading test were 37 valid and reliable multiple-choice items. The researchers adopted Gilbert's (Dhindsa & Treagust, 2009) category of high at >75 , medium at $60 \leq$ and ≤ 75 , and low

at < 60 .

The qualitative data collection was conducted to obtain the description of the students' metacognitive skill profiles in solving the problems. The research subject was randomly picked from low ability level students, who were given the symbol of S1, S2, S3, S4, etc. The subject was chosen in consideration with the highest understanding percentage (87% of 71 students), compared to other two levels of understanding.

The information about the students' metacognitive skills in solving the problems was obtained by giving problems to the S1 and S2 student. The given problems were adapted from Silberberg (2007) and were given the symbol of M1 and M2. The students solved the problems through think aloud (Olson et al., 1988; Ferguson et al., 2012) and triangulated the data through an interview. The interview was a combination of the structured and unstructured interview. The problems were assigned repeatedly at a different time (time triangulation) so that the students would consistently solve the problems. The explorative results of problem-solving using *think-aloud* along with interview were described and analyzed, referring to Miles et al. (2013) to obtain the students' metacognitive skill profiles.

RESULTS AND DISCUSSION

The analysis of the students' metacognitive skills in solving Chemistry problems, initiated by S1 and S2 in solving M1. A week later, both students had figured out the M2 (time triangulation). The triangulation results showed that there was a consistent meaning of the students (S1 and S2) in solving the problems at a different time. The consistency indicated that the students' data in figuring out M1 and M2 were credible. Hence, both students' metacognitive skill profiles appeared in M1 or M2.

The problems assigned to the students were; (M1) Vitamin C with a molar mass of 176,12 gr/mol is one of the hydrogen compounds which is naturally found in oranges. To determine vitamin C's molecular formula, some oranges are extracted so that it is obtained 5 grams of vitamin C. 1,00 gram of the sample is placed in a combustion chamber, which is as follows:

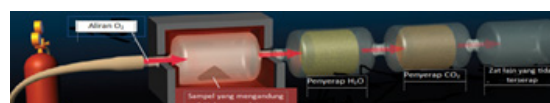


Figure 1. the Combustion Chamber, 37,55 grams

of $\text{Mg}(\text{ClO}_4)_2$ was used and in the CO_2 absorbent tank, 83,85 grams of NaOH was used. After the combustion, the mass of $\text{Mg}(\text{ClO}_4)_2$ turned to 37,96 grams and NaOH's mass turned to 85,35 grams. a) make a plan to figure out the problem! b) finish by your plan! c) If you have solved the problem, check the results! Are you sure that your answer is correct? Leave a comment!; (M2) During the process of human physical activity, lactic acid with a molar mass of 90.08 grams/mol is formed in muscle tissue and causes muscle pain. An analysis is conducted to determine the molecular formula of lactic acid, shows that the compound contained 40.0% mass of element C; 6.71% mass of element H; and 53.3% mass of element O. a) make a plan to figure out the problem! b) finish by your plan! c) If you have solved the problem, check the results! Are you sure that your answer is correct? Leave a comment!

The elaboration of students' thinking processes in solving the problems to determine their metacognitive skills profiles describes as follows:

The Illustration of S1 in Answering the M1: The S1's Planning Skill in Solving Problems

The S1 read the M1 as directed by the researchers. After reading the problem, the S1 continued the statement in answering M1. Here are some excerpts of interviews with the S1:

Researchers: [have you understood the statement in the matter?]

S1 : explicitly answered that the problem is how to determine the formula of vitamin C molecules (while rewriting the problems given on the blank paper). S1 continued the assertion that the data available in this problem is mass ... mass (stammer), i.e. $\text{Mg}(\text{ClO}_4)_2$ and NaOH mass before and after the combustion of vitamin C. In addition, the mass of vitamin molecules C was known at 176.12 gram/mol. Other given data stated that the mass of vitamin C sample used was 1 gram. Here are the planning results made by the S1 during think-aloud:

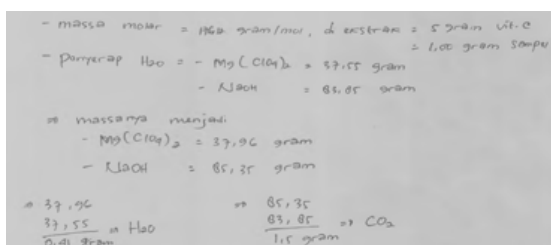


Figure 2. The S1's Planning Results

The statement expressed that S1 could translate part of the problem well by demonstrating his/her ability to identify the problem and objectives expected on M1. This result was the first step that would guide the S1 in solving the problem. According to Hacker et al. (1998); Me-

tallidou (2009); and Balcikanli (2011), metacognitive skills are initiated by planning. Skills that may arise in the planning stage are setting goals and choosing the right strategy, and strategy made by S1 was;

Handwritten notes showing the S1's strategy for solving the problem:

1. pada tahap awal, kita harus menentukan atau mencari massa H₂O dan CO₂ yang terakap dan menentukan massa H dan C dan persentase H dan C dan menentukan atau mencari massa O
2. Mencari mol C, H dan O dan menentukan atau mencari rumus empirisnya (RE).
3. Menentukan rumus molekul dan vitamin C tersebut

Figure 3. The S1's Strategy

The strategy formula given by the S1 showed that s/he understood what was needed in determining the molecular formula. This corresponded to the interview quotes in which the S1 stated that to determine the molecular formula, the empirical formula must be first determined.

The S1's ability to identify the data required in determining the molecular formula went along with his/her ability to construct a problem-solving strategy. Therefore, it said that the S1 could connect between what was known and what was needed in solving the problem. This situation is supported by the opinion of Sesen & Tarhan (2013) who stated that when learners are solving a problem, information about the problem (through understanding) is assembled into the working memory represented by a tree. One part of the tree contains 'known' while the other part involves 'unknown'. The long-term memory then looks for rules or relationships between the 'known' and 'unknown' in order to modify the working memory structure to achieve the solution to the problem. Searching for relevant information from memory occurs through two processes, which takes the information from long-term memory and decides whether or not the earned information is something necessary.

The S1 case showed that information could be drawn from long-term memory when there was a concept of empirical and molecular formula. The ability of S1 to relate the 'known' and 'unknown' (the goal achieved) is one of the causes of the S1's ability to develop problem-solving strategies resulting in goal achievement. This is in line with Sesen & Tarhan (2013) as described above.

The S1's Skills in Completing and Monitoring the Problem-Solving Process

The S1 answered the problem in accordance with the determined plan. The problem-solving process was done step by step until the empirical formula was determined. The following are given empirical formula (EF) determinations found in the S1's *think-aloud*:

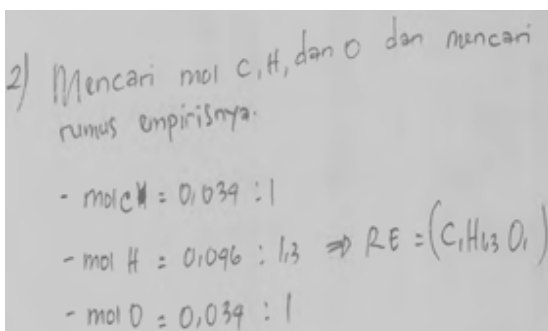


Figure 4. The Empirical Formula by the S1

According to the S1 (obtained from interview), the empirical formula is the smallest comparison of the atomic mole numbers of C, H, and O constituting the vitamin C molecules. This finding showed that the S1 only focused on determining molecular formulas and no longer monitored the empirical formulas obtained. The S1 basically could monitor the empirical formulas obtained by raising questions (Lazakidou & Retalis, 2010; Kaberman & Dori, 2009). The emerged questions could be 'Is it possible that there are at least 1.3 H atoms in the molecule?', 'Is there an atom in the number of fractions when it forms a bond with another element?'

These questions were not proposed by the S1 during the problem-solving process. It said that the S1 did not monitor the process of solving the problem even though the planning stage required monitoring and re-checking to achieve the expected results. This finding is in line with Desoete's (2007) opinion that monitoring skills are a one-man oversight activity against the cognitive strategies employed during the task performance in order to identify problems and modify plans. This monitoring activity cannot be separated from the planning and evaluation done by a person to be successful in solving a problem. Hacker et al. (1998) also reported that the metacognitive skill components such as planning, monitoring, and evaluation are interconnected or complementary to each other for achieving the goals.

The S1's Evaluation Skill in Solving Problems

The final results obtained by S1 was finding out molecular formula of vitamin C by comparing the vitamin C's molar mass with the empirical formula's molar mass discovered at the previous step. The following is given the final results of S1 through *think-aloud*:

The results of the problem-solving were then evaluated by the S1. The result of evaluation done by the S1 through *think-aloud* is as follows:

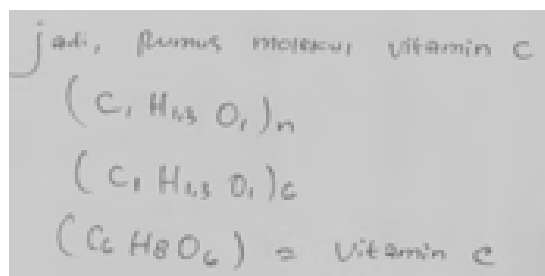


Figure 5. The S1's Final Results

Karena pada persamaan (angka pertama absorber H₂O ya diserap, menyerap H₂O menggunakan Mg(ClO₄)₂ dan menyerap CO₂ menggunakan Al₂O₃ kemudian mulai luncurnya molar - molar 37,01 gram, sebagai di beri partikel terhadap mesin berakut massa Mg(ClO₄)₂ bertambah menjadi 37,96 gram, bertambah massa Mg(ClO₄)₂ karena Mg(ClO₄)₂ mengambil H₂O atau sampai H₂O di ambil oleh Mg(ClO₄)₂, ketika di ambil massa Mg(ClO₄)₂ bertambah. Dan lanjut Al₂O₃ atau menyerap CO₂ sampai CO₂ massanya bertambah. Sehingga berdasarkan persamaan penyediaan rencana diatas dan didapatkan rumus molekul vitamin C yaitu : $(C_6H_8O_6)$

Figure 6. The S1's Evaluation Results

The reason given by the S1 was neither a proof of the truth accompanied by the logical reasoning of the solution nor the examining result in relation to the concepts involved in the problem. In line with this, Miller, et. al. (2009) stated that evaluation skill is the ability to contemplate to give consideration to a problem-solving process using a certain benchmark. Sesen & Tarhan (2013) also argued that the evaluation skill of problem-solving results could be measured from students' ability to use cognitive variables on connecting skills, which associates the concepts underlying a problem to convince the truth of the solution. The use of cognitive variables and logical reasoning is the key to predict subsequent success (Bunce & Hutchinson, 1993; Byars-Winstion & Fouad, 2008). The use of cognitive variables and logical reasoning is not an explanation of the relationship between the results and the problem of statement as performed by the S1. Therefore, the S1 had not done the evaluation skills.

The Illustration of the S2 in Answering the M1 The S2's Planning Skill in Solving Problems

The S2 read the M1 as directed by the researcher. After reading the problem, the S2 continued the statement in the completion of M1. Here are some interview excerpts and *think-aloud* on the S2:

Researchers: [have you understood the statement in the matter?]

S2 : Explicitly stated that s/he understood the problems given. The goal was to determine the molecular formula of vitamin C.

The steps done to accomplish the goal were:

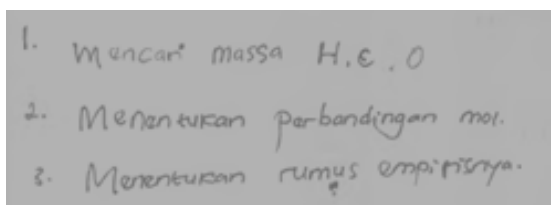


Figure 7. The S2's Planning Results

The S2 continued his/her statement that the provided data were employed to answer the question based on the steps which were as follows:

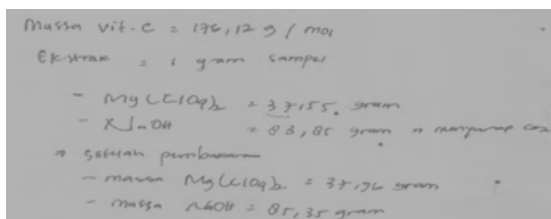


Figure 8. The S2's Strategy

The results of interviews and *think-aloud* showed that the S2 was able to explain the function of NaOH as a CO₂ absorber after repeatedly reading the problem. However, s/he could not explain the function of Mg(ClO₄)₂, since the S2 believed that the combustion process of Vitamin C only produced CO₂. Therefore, in the identification section of the problem, the S2 wrote the mass and function of NaOH but did not write the function of Mg(ClO₄)₂.

Based on the obtained results, it said that the S2 had not understood the matter well since s/he did not surely state that there were two compounds produced from the combustion of vitamin C, CO₂, and H₂O. Moreover, the S2 was known to lack of initial knowledge on combustion of a hydrocarbon compound so that s/he could not assimilate into his/her possessed knowledge and obtained knowledge. Therefore, there were four planning variables that the S2 had not achieved during the process i.e. problem-analyzing skill,

conceptual linkage, idea association, and specific knowledge relevant to the problem. According to Sesen & Tarhan (2013), planning skills require six variables, namely; problem-solving skills, problem-solving experiences, conceptual interrelationships, idea associations, specialized knowledge, and specialized but irrelevant knowledge.

Seeing the above results, it shows that the S2 has had the problem-analyzing skill by demonstrating his/her ability in sequence, determining the expected objectives, selecting a settlement strategy, and identifying the problem. The sequence of thinking skills conducted by the S2 was a strategy to make it easier to solve the problem (a piece of information from interviews on the S2) even though the strategy prepared by the S2 was incomplete to answer the problem well. According to Desoete (2007), planning skills refer to the initial activity of one's thinking about how, when, and why s/he takes action to achieve the goal through a series of specific goals toward the main goal of the problem. This opinion supports the thinking skills of the S2. The S2 was expected to use planning skills by answering his/her own question such as "how to determine molecular formulas?". Another question predicted to appear in the S2 thinking process was "why should we do some actions in the strategy?" (Lazakidou & Retalis, (2010); Kaberman & Dori, 2009). This statement was corroborated by the interview results with the S2 that the molecular formula of vitamin C could be determined by discovering the empirical formula first. Therefore, the activity of preparing the strategy was done initially before deciding the supporting data required in solving the problem.

The S2's Skills in Answering and Monitoring the Problem-solving Process

The S2 tried to solve the problem according to the decided strategy but s/he did not do it structurally based on the steps made. The following is parts of the S2 in the problem-solving process.

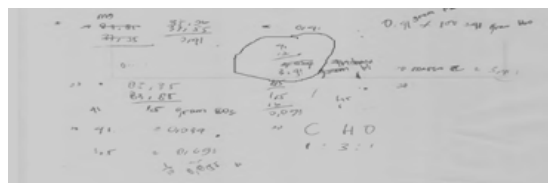


Figure 9. The S2's Problem-Solving Process

Based on the problem-solving data in the picture above, the S2 directly determined the mass of C and H from the calculation of the different mass of both absorbers used. The S2 had no

idea that the difference was on the mass of CO₂ and H₂O instead of C and H. In addition, the S2 calculated and found a mass of C in a sample of 3.41 grams (in a circle sign). The S2 did not use his/her monitoring skills by logically thinking that the sample mass used was only 1 gram. Why does the C mass that is only a part of the vitamin C's atomic molecule have a far greater mass than the samples? Hacker et al. (1998) revealed that planning, monitoring, and evaluation, all three are interconnected or complementary to each other for the same goal. The inability of the S2 to plan as well as solve problem made s/he was also incapable of using monitoring skills because these skills are interconnected and complementary. In other words, the S2 was not skilled to solve the problem well.

The S2's Skills in Evaluating the Problem-solving Results

The S2 did not obtain the solution to the problem so as *not to use the evaluation skills to evaluate the problem-solving results*.

CONCLUSION

According to the result of the research, it concluded that chemistry education students with a low level of chemistry skills in solving a problem employed planning skill to identify a problem, to determine a goal, and to compile strategy. However, the students did not use the metacognitive skill of monitoring and evaluating since they tended to potentially fail to solve the problem.

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THE INFLUENCE OF ANDROID-BASED ISOMORPHIC PHYSICS (FORFIS) APPLICATION ON ANALOGICAL TRANSFER AND SELF-DIAGNOSIS SKILL OF STUDENTS AT SMA NEGERI 3 KUPANG

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ABSTRACT

This research intended to understand the effect of Isomorphic Physics (FORFIS) application to the analogical transfer and self-diagnosis skill of high school students. The use of Android applications in physics learning has given a considerable influence in improving the various abilities of learners. However, no one has measured the influence of the Android application on the analogical transfer and self-diagnosis skill of students, especially in physics subject. This research type was experimental research of pre-test post-test control group design. The subjects involved in this research were 1 physics teacher and 87 students of SMA Negeri 3 Kupang; 28 students in the experimental class I (G1), 35 students in the experimental class II (G2), and 24 students in the experimental class III (G3). The data obtained were analyzed using the ANOVA Mixed Design method in combination with General Linear Model. The results of the analysis show that the FORFIS application could improve 0.912 or 91.2% of the students' analogical transfer and self-diagnosis skill. Therefore, the FORFIS application employed in physics learning had a great influence on the improvement of analogical transfer and self-diagnosis skill of high school students.

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Keywords: isomorphic, physics, android, analogical transfer skill, self-diagnosis skill

INTRODUCTION

The involvement of technology in the educational environment requires creative and innovative educators in using technology in learning. Technological developments ultimately lead to changes in educational settings (Robinson & Reinhart, 2014; Eliana et al., 2016; Wardani et al., 2017; Usmeldi et al., 2017). One of the devices that could be utilized for educational purposes is the Android-based smartphone (Calimag, et al., 2014). Interactive skills, easy access, and fun are some advantages provided by this device (Hanafi & Samsudin, 2012). This causes learners

having a tendency towards the use of the Android-based smartphone. The Android-based smartphones facilitate learners in accessing multimedia resources, and studying anytime and anywhere (González et al., 2015). The type of learning media that can be operated using this device is an Android-based learning app. The utilization of Android-based learning applications in education is one of the XXI Century learning styles (Calimag et al., 2014). Some research on the use of Android applications in physics learning gave very satisfactory results. The use of Android applications in physics learning could improve the ability of mathematical representation and the interpretation of electrical circuits (Yadiannur & Supahar, 2017), learning independence, conceptual understanding (Arista & Kuswanto, 2018),

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independent thinking skills, and High Order Thinking Skills (Mardiana & Kuswanto, 2017). These studies provided very important information on the use of Android applications in physics learning.

The use of Android applications in physics learning has a considerable effect on the improvement of the students' various abilities. However, the use of Android apps in physics learning has not been measured its influence on the analogical transfer and self-diagnosis skill of students. One of the Android apps that could be utilized to measure the analogical transfer and self-diagnostic skill is the Android-based Isomorphic Physics (FORFIS) application. The FORFIS application is an Android-based learning media that I developed myself. The application contains isomorphic questions that refer to the indicators of analogical transfer skill. In addition, this application also carries three different problem features. All three features in the FORFIS application aims to provide repetition of problems on a regular basis so that learners can train their skills (Sari, 2018). The question features are the question examples, exercise questions, and quizzes that are isomorphic on Momentum and Impulse materials. The sample problems in the FORFIS application included in the discussion are in accordance with the problem-solving steps. The problems contained in this application have been declared worthy of use both to train and measure the analogical transfer skill. Although it has been developed, this application has not been tested to determine its influence in improving the ability of learners.

The analogical transfer skill defines as an ability to transfer familiar problem-solving knowledge to solve new problems (Docktor & Mestre, 2014; Eysenck & Keane, 2010; Lin & Singh, 2013^a; Lin & Singh, 2013^b; Mason, et al., 2009; Monaghan et al., 2015; Robertson, 2017; Santrock, 2011; Stevenson, et al., 2013; Storm & Bui, 2016). The transferring activities have continuously happened even though there are differences in each problem features (Casale, et al., 2012). Though the problem is different, the resolution process has the same steps (Eysenck & Keane, 2010; McBride & Cutting, 2016). Thus, the analogical transfer could define as an ability to solve new problems using the acquired knowledge. Furthermore, the self-diagnosis skill is a learner's ability to identify and explain self-made errors (Yerushalmi, et al., 2008; Yerushalmi et al., 2012). In addition, Putri et al. (2015) defined the self-diagnosis skill as a diagnosing or identifying process of the conditions within one-

self. The diagnosed object in practicing the self-diagnosis skill is a solution to solve problems that have been answered by their own (Safadi, 2017). The self-diagnosis skill in this study defines as a process of identifying and explaining errors of the examined problem-solving steps.

In relation with the analogical transfer skill, the results of the study conducted by Brokes et al. (2011) provide information that giving the problem-solving exercise to the student on algebra and calculus programs could improve their analogical transfer skill. Furthermore, the research related to the self-diagnosis skill has done by Yerushalmi et al. (2012). Through their research, we know that students' value of the self-diagnosis skill correlates with problem-solving skills. The performance of self-diagnosis could influence the success in transferring knowledge towards the encountered problems. This means that the analogical transfer skill influences the self-diagnosis skill.

High school students have a tendency to transfer their knowledge to new problems and diagnose mistakes that have been made. This information was obtained from interviews with some high school teachers in Kupang city, and observations conducted at several senior high schools in Yogyakarta. The students' tendency appeared when they were asked to solve physics problems. While solving the same problem as the given example, most students were able to finish well. However, when the given problem has little difference in the problem-solving steps, most students experienced difficulty. The difficulties the students experienced arose because of the paradigm that the final answer is the sole purpose of problem-solving. Therefore, it is important to do research related to learning media that could be utilized to improve the analogical transfer skill and self-diagnosis skill.

The solution offered to help students overcome their tendency is providing practice questions containing indicators of analogical transfer. The goal is to train students' analogical transfer skill and, indirectly, self-diagnosis skill. The questions given could be obtained from various sources. One of the learning media that include the problems having the indicators of analogical transfer is the FORFIS application. The previous research by Brokes et al. (2011), employed exercise questions with paper and pencils method, while in this research the method used was categorized by the current technological development. Therefore, this research utilized Android app as a learning media. This application was compared with the learning media usable for teachers i.e., handouts and whiteboards. Thus, the focus of this

study was to analyze the influence of FORFIS Application in improving the analogical transfer and self-diagnosis skill of high school students.

METHODS

This research employed quasi-experiment method with pre-test post-test control group design (Abdurrahman, et al., 2018). The research was conducted at SMA Negeri 3 Kupang, East Nusa Tenggara. The research subjects involved in this study were 1 physics teacher, 28 students in the experimental class I (G1), 35 students in the experimental class II (G2), and 24 students in the experimental class III (G3). The design of this study is presented in Figure 1.

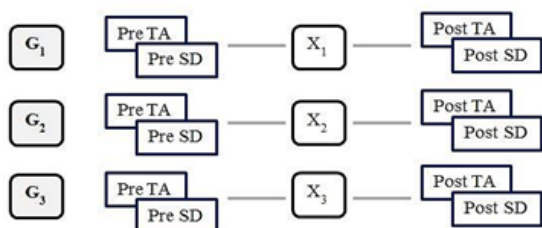


Figure 1. The Research Design of Pre-Test Post-Test Control Group Design

Each experimental class was given different media. The experimental class I (G1) used the FORFIS app, the experimental class II (G2) employed a handout, while the experimental class III (G3) utilized the blackboard as a medium. However, all three classes obtained the same topic. The difference took place in the way of obtaining questions.

The data of analogical transfer and self-diagnosed skill were obtained from the analogical transfer skill pre-test (PreTA) and post-test (PosTA), as well as self-diagnosis skill pre-test (PreSD) and PostSD. The research began with the PreTA followed by PreSD. The PreSD activities were performed by diagnosing mistakes when answering PreTA questions. Data analysis technique employed was Anova Mixed Design in combination with General Linear Model. This analysis technique was called Anova Mixed Design as it combines two sub-analysis. This technique was used to test the difference in the group score 1 (pre-test vs. post-test) and the group score 2 (G1, G2, G3). Therefore, the analysis technique adopted was also called the Anova Mixed Design 2 x 3. The purpose of adopting this technique was to analyze the influence of media usage in such learning. Prior to the analysis, the data normality and homogeneity were

examined. The data normality was tested using the Kolmogorov-Smirnov test which stated that the data was declared normal if the sig. >0.05. The data homogeneity test employed the Levene test which categorized data as homogeneous if the sig. >0.05. The data analysis using the Anova Mixed Design in combination with General Linear Model in this research only considered the influence of media usage in learning. The results obtained were seen on partial eta square values. The greater the value of partial eta square, the greater the influence of media used in learning.

RESULTS AND DISCUSSION

This research used the FORFIS application as learning media. The purpose of using the FORFIS application was to find out the influence of FORFIS application in improving the analogical transfer and self-diagnosis skill. The learning activities carried out by the teacher using a scientific and lecturing approach in combination with demonstrations and exercises. After the teacher presented the provided materials, then s/he used the existing media to each experimental class to rehearse the students' analogical transfer and self-diagnosis skill. The learning activities were conducted three times, and the learning steps were split up into three stages of introduction, core, and closing. The PreTA and PreSD were carried out at the introduction stage. The core learning activities adopted the scientific approach consisting of observing, asking, trying, reasoning, and communicating. The use of the FORFIS application in learning lied in the trying and reasoning part. The students were asked to work on the exercise questions and quizzes contained in the FORFIS application. After the three meetings were held, the students were then given the PostTA followed by the PostSD.

This study intended to determine the influence of FORFIS application on the analogical transfer and self-diagnosis skill of high school students. Prior to the analysis, the data normality and homogeneity test were carried out. In short, the significance values of normality and homogeneity test results are presented in Table 1. The information in Table 1 is the data of PreTA, PreSD, PostTA, and PostSD results in each experimental class showing the significance value of normality test which was greater than 0.05. This means that the overall data obtained from the research results were normally distributed. The significance value of homogeneity test results from PreTA, PreSD, PostTA, and PostSD in each experimental class

was also greater than 0.05, which means that the overall research data had the same variance. The research result data that have been stated normal

and homogeneous then were analyzed to know the influence of media used in physics study.

Table 1. The Significance Value of the Obtained Data's Normality and Homogeneity Test

Class	Type of Research	Sig. Normality Test	Sig. Homogeneity Test
G ₁	PreTA	0.176	0.149
	PreSD	0.129	0.533
	PostTA	0.104	0.236
	PostSD	0.353	0.102
G ₂	PreTA	0.087	0.719
	PreSD	0.120	0.414
	PostTA	0.090	0.226
	PostSD	0.159	0.412
G ₃	PreTA	0.489	0.893
	PreSD	0.249	0.250
	PostTA	0.115	0.408
	PostSD	0.228	0.589

The analysis results of the increase in the students' analogical transfer skill are presented in Figure 2. It tells that the students' early analogical transfer skills in each experimental class tended to be the same. The similarity of the initial analogical transfer skill of students was because the three experimental classes were the leaded classes for the science majors. After utilizing different media in each experimental class, such skill has increased significantly. It appears in Figure 2 that the students' analogical transfer skill in the class using FORFIS application (G1) was higher than that using handout (G2) and whiteboard (G3), while both (G2) and (G3) were likely to be the same. This means that of the three media applied in the lesson, the most effective was the FORFIS application.

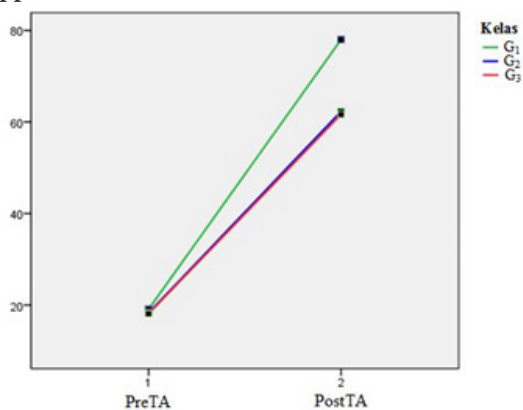


Figure 2. The Increase of Analogical Transfer Skill Graph

Next, the results of the self-diagnostic skill enhancement analysis are presented in Figure 3. The information provided is that the students' prior self-diagnosis skill in each experimental class was likely to be the same. However, after using different media in each experimental class, the students' self-diagnosis skills have increased significantly. This is presented in Figure 3, the students' self-diagnosis skill after learning using FORFIS application (G1) was higher than that using handout (G2) and whiteboard (G3), while both (G2) and (G3) did not differ significantly. This indicates FORFIS application was the most effective instructional media to improve the students' self-diagnosis skill compared to the others.

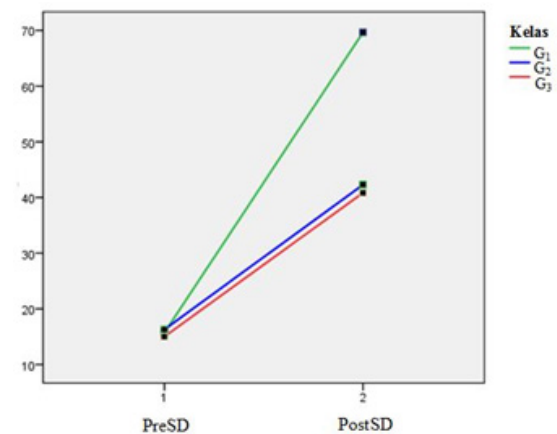


Figure 3. The Increase of Self-Diagnosis Skill Graph

The use of FORFIS application in physics learning showed a considerable increase compared to using other media. Various conveniences such as helping in solving problems, beneficial in learning to make learning more interesting and motivating students for improvement. The students' response to the ease of the FORFIS application was very well. The use of FORFIS application in learning could help students solve physics problems. The students' response to the benefits of using Isomorphic Physics application in learning showed that they need FORFIS application in classroom learning. In addition, the students also considered the FORFIS application as interesting learning media and motivate them to learn. The ease the FORFIS application provided has triggered an increase in the analogical transfer and self-diagnosis skill. Thus, it concluded that the use of FORFIS application in learning could significantly increase the analogical transfer and self-diagnosis skill.

Furthermore, the analysis results of the instructional media influence in each experimental class are presented in Table 2. If two dependent variable groups are used, the multivariate significance appears in the Hotelling's Trace. Whereas, if more than 2 groups of dependent variables are employed, the multivariate significance appears in the Wilks' Lambda. Partial Eta Squared's value describes the Effect Size or how much influence/contribution was given to improve the analogical transfer and self-diagnosis skill of the learners. Table 2 shows that there were four dependent variables involved in the PreTA, PreSD, PostTA, and PostSD, with three experimental classes. Therefore, multivariate significance appeared in the Wilks' Lambda (Ghozali, 2013). It informs that the use of FORFIS application media devoted 0.912 or 91.2% in improving the students' analogical transfer and self-diagnosis skill. Moreover, the use of handout media contributed 0.868 or 86.8%, and the use of whiteboard gave 0.819 or 81.9%. The FORFIS application in learning contributed enormously. That was due to the FORFIS application content including examples, exercises, and quizzes that were isomorphic problems. The examples in the discussion are in accordance with the problem-solving steps. The problems contained in the FORFIS application indirectly improved the analogical transfer and self-diagnosis skill. Although the overall experimental class has improved, the ease

of obtaining learning source was also an improving factor in each experimental class. The FORFIS application made it easy for students to get a learning resource as it was installed on their personal smartphone so they could learn at any time and place. The contribution given by each experiment class was quite high. Thus, of the three media used in learning, the FORFIS application devoted most in improving the students' analogical transfer and self-diagnosis skill.

Table 2. The Analysis Results of the Media Usage Influence on the Analogical Transfer and Self-Diagnosis Skill

Class		F	Sig.	Partial Eta Squared
G ₁	Wilks' lambda	2.841E2 ^a	.000	.912
G ₂	Wilks' lambda	1.793E2 ^a	.000	.868
G ₃	Wilks' lambda	1.239E2 ^a	.000	.819

In addition, the analysis was done separately to determine the effect of media on each variable. The data analysis results are presented in Table 3. This analysis involved two dependent variables i.e., the PreTA and PostTA. Therefore, the significance emerged in the line of Hotelling's Trace (Ghozali, 2013). It tells that the use of FORFIS application in improving the analogical transfer skill of students devoted 0.895 or 89.5%, the use of media handouts contributed 0.856 or 85.6%, and the use of whiteboard media granted 0.800 or 80.0%. Based on Table 3, it indicates that the FORFIS application was more influential than other media. This great influence was due to the isomorphic problems with the completion step according to the indicators of analogical transfer contained in the FORFIS application. Isomorphic problem-solving indirectly trained students' analogical transfer skill. In other words, the FORFIS application devoted most in improving the students' analogical transfer skill.

Table 3. The Analysis Results of the Media Usage Influence on the Analogical Transfer Skill

Class		F	Sig.	Partial Eta Squared
G ₁	Hotelling's trace	7.155E2 ^a	.000	.895
G ₂	Hotelling's trace	4.993E2 ^a	.000	.856
G ₃	Hotelling's trace	3.353E2 ^a	.000	.800

The analysis results of the media usage influence on the students' self-diagnosis skill are presented in Table 4. This analysis involved the PreSD and PostSD. In accordance with the terms given, the significance of the analysis result emerged in the Hotelling's Trace. Table 4 informs that the use of FORFIS application in improving the students' self-diagnosis skill granted 0.817 or 81.7%, the use of handouts contributed 0.565 or 56.5%, the use of whiteboard devoted 0.468 or 46.8%. Table 4 provides information that the use of the Isomorphic Physics application had a greater impact than the use of other media. That was because the FORFIS application contains examples, exercises, and quizzes. Through the example, the students could find how to solve a problem. The exercises given with the answers were to compare the students' result of the problem with the example. The quizzes trained students to correctly answer the given questions. These three content indirectly trained students to diagnose their mistakes in solving problems. In sum, the FORFIS application contributed most to improve the students' self-diagnosis skill.

Table 4. The Analysis Results of the Media Usage Influence on the Self-Diagnosis Skill

Class		F	Sig.	Partial Eta Squared
G ₁	Hotelling's trace	3.750E2 ^a	.000	.817
G ₂	Hotelling's trace	1.090E2 ^a	.000	.565
G ₃	Hotelling's trace	73.756 ^a	.000	.468

Based on the analysis results of the media usage influence, it concluded that the use of FORFIS application granted a considerable influence in improving the students' analogical transfer and self-diagnosis skill. The experimental class adopting the FORFIS application ranked first, followed by the (G2) and (G3) which respectively adopted handouts and whiteboards.

The use of FORFIS application in physics learning gave a noticeable effect in improving the analogical transfer and self-diagnosis skill of the learners. Based on the learners' response to the use of FORFIS application in learning, they said that the app helped them solve problems, was useful in learning, made learning more interesting and motivated. The various facilities offered by the FORFIS application in learning were known through a questionnaire response given to the 28 students joined in the (G1). Their response to these various factors was very good. This statement was strongly approved by 22 students, which means that the Isomorphic Physics application was very easy for learners in solving encountered physics problems. Moreover, there were 27 students who stated that the application was very useful, indicating that the students needed the FORFIS application in the learning process. In addition, there were 27 students who agreed that the FORFIS application is interesting, and 23 of them believed that the app could motivate them. The more they were motivated, the more knowledge they would acquire. Hence, the FORFIS application was greatly improved the students' analogical transfer and self-diagnosis skill.

The effect of using FORFIS application in learning provided a large partial eta square value. That was due to the features provided by this application aims to improve the students' analogical transfer and self-diagnosis skill. The question featured with isomorphic problems referring to the indicators of analogical transfer skill. This type of problem was available in example questions, exercise questions, and quizzes. The students who were diligent in working on the problems contained in the application gradually formed the analogical transfer in accordance with the problem-solving steps provided. Therefore, the application was said to be the learning media that helped improve the analogical transfer skill with a great influence of 89.5%. In addition, the use of FORFIS application in learning could also improve the student' self-diagnosis skill with a considerable influence that was 81.7%. However, the FORFIS application did not influence the self-diagnosis immediately. Increasing the self-diagnosis skill was closely related to the increased the

analogical transfer skill (Yerushalmi et al., 2012). The results of the analysis showed that partial eta values of the use of FORFIS application in improving the analogical transfer and self-diagnosis skill were not much different. It proved that these two skills were connected. Thus, it concluded that the use of FORFIS applications in learning gave a considerable influence on the students' analogical transfer and self-diagnosis skills.

The use of the Android application in physics learning provided various facilities for the learners to obtain learning resources (Hanafi&Samsudin, 2012). By utilizing the trends that millennial learners have in this digital age, educators are easier in implementing learning both inside and outside the classroom. Learners no longer need to bring a lot of resources in the form of a textbook. Only by bringing the Android-based smartphone, students could have learning resources. These conveniences offered help learners to learn at anytime and place. Thus, the use of Android-based learning applications in the world of education is the XXI century learning style. This statement is supported by the research results conducted by Calimag et al. (2014).

CONCLUSION

This study was conducted to determine the influence of FORFIS application usage in Physics learning on the students' analogical transfer and self-diagnosis skill. The influence was measured either individually or both kind of skills. The results showed that the FORFIS application devoted enormously in improving the students' analogical transfer and self-diagnosis skill. The Isomorphic Physics application also greatly contributed to each skill individually. Therefore, the FORFIS application used in physics teaching in schools had a major effect on improving the students' analogical transfer and self-diagnosis skill.

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THE RECONSTRUCTION OF DISASTER KNOWLEDGE THROUGH THEMATIC LEARNING OF SCIENCE, ENVIRONMENT, TECHNOLOGY, AND SOCIETY INTEGRATED WITH LOCAL WISDOM

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ABSTRACT

This study aimed to improve the mastery of knowledge, attitudes, and skills of students in disaster mitigation in prone areas of volcanic eruptions. The subjects of this research were fifth (V) graders in three elementary schools situated in prone areas of Merapi volcano eruption in Srumbung subdistrict, Magelang regency, Central Java. The data collected in this study consisted of disaster knowledge, attitude, and disaster mitigation practice. The data of disaster knowledge were obtained through a test and analyzed using t-test and N-gain. The attitude data were collected using questionnaire with an improvement analysis using N-gain. The mitigation practice data were collected through observation and analyzed by descriptive percentage for attitudes and skills. The research results showed that the implementation of thematic learning of Science, Environment, Technology, and Society (SETS) integrated with local wisdom was able to reconstruct and increase the disaster management knowledge. This can be seen from the N-gain score obtained by each elementary school which the highest Gain Score was 0.46 and included in the medium category. There was an enhancement attitude toward disaster having the highest Gain Score was 0.77. All disaster mitigation indicators were successfully mastered by more than 70 percent of the students, who were in the good category ($70 \geq X \leq 85$) in all three elementary schools implementing the thematic learning of SETS integrated with local wisdom.

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Keywords: disaster, local wisdom, reconstruction, thematic learning

INTRODUCTION

Climate change occurred in many regions in the last five years has resulted in various disasters. Disaster is a natural event to watch out for. Global climate change also affects all areas including Indonesia. Many disasters frequently happen in Indonesia are floods, earthquakes, landslides, and volcanoes. Indonesia archipelago has a very high disaster potential which varies greatly on disaster types. The application of plate tectonic

theory for the Indonesian is due to its location on a crustal plate clash of the Eurasian / Southeast Asia, Pacific, and the Indo-Australian. In addition to the complexity of demographic, social and economic conditions in Indonesia that contribute to the high level of community vulnerability to disaster threats, as well as the people's lack of capacity in dealing with disasters, Indonesia has a high risk of disaster. In 2017, volcanic eruptions occurred several times just as at Karo District, North Sumatera. The high-level intensity eruption of Sinabung Mountain, for instance, happened twice on Saturday, May 20, 2017, and

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Wednesday, August 2, 2017. Another eruption took place at Gunung Agung in Bali province which also erupted on Tuesday 21 November 2017 at 17.05 WITA. The high intensity of volcanic eruption disaster is caused by the number of active volcanoes in Indonesia. Indonesia has 127 active volcanoes scattered on large and small islands. The big number of active volcanoes in Indonesia as it lays on the Pacific ring of fire.

Indonesia's geographical position on the Pacific Ring of Fire causes the high level of volcanic eruptions (Siagian et al., 2014). The volcanic eruptions have a long-term impact. The burst of volcanic materials could alter the existing ecosystem in the slopes. In addition to the environmental impact, volcanic eruptions also affect the people's social life. One of the mountains with a high level of activity in Indonesia is Mount Merapi (Carr et al., 2016; Troll et al., 2015). Mount Merapi is situated on the border area of Central Java and the Special Region of Yogyakarta. Up to now, Mount Merapi has erupted more than 80 times, once every 4 years on average. The last eruption of Mount Merapi occurred in 2014 having 347 casualties. The area with the highest number of casualties was Sleman Regency (246 people), Magelang District (52 people), Klaten (29 people), and Boyolali (10 people). Moreover, the refugees due to the Mount Merapi eruption were 410,388 people (Renatama, & Suryono, 2015; Susilo & Rudiarto, 2014).

Due to Merapi's high intensity of eruption and its large number of casualties, it requires concrete steps to diminish the risk and casualty number. One of them is by transferring the knowledge about disaster alertness in schools through learning activities. The lesson about disasters is certainly different from the ordinary lesson that does not include such knowledge (Rusilowati et al., 2012). Disaster learning should be designed considering the disaster-prone areas, disaster characteristics and early knowledge about disasters. Basically, the people living in disaster-prone areas already have unpretentious knowledge on disaster management which is hereditarily derived from older family members. This acquired knowledge is both facts and myths, which generally can be elucidated scientifically. However, some myths flourish in the certain area.

One of the efforts to fix, reconstruct and improve community's disaster knowledge is through disaster education at schools (Tasic & Amir, 2016; Dwiningrum, 2017). In line with this, knowledge reconstruction, attitude, and

competence of disaster mitigation improvement of the people living on slopes of Mount Merapi through the series of school activities were undertaken. Disaster education activities in schools through learning activities require a learning design integrating disasters, knowledge of the community, environment, technology, and local wisdom. To realize it, the learning of Science, Environment, Technology, and Society (SETS) integrated with the local wisdom is one of the solutions. The SETS thematic learning educated the students to linkage the science concepts with other elements in SETS. Such a way allowed the students to gain a clearer description of the learning conceptual association with other SETS elements both the advantages and disadvantages (Binadja, 2005). The integration of local wisdom in the lesson could be implemented in some subjects. The first thing to be doing is mapping the subjects to which the SETS learning is applicable. This has to be carefully undertaken to result in a harmonious integration without any overlapping. (Setiawan et al., 2017; Rusilowati et al., 2015; Andriana et al., 2017).

Similar research has been done by Setiawan et al. (2017), who developed a local wisdom-based Natural Science module to enhance students' science literacy. Furthermore, an article written by Rusilowati et al. (2015) discusses how to apply the SETS thematic learning in teaching disaster knowledge integrated with local wisdom. While in this research, the SETS thematic learning integrated with the local wisdom of Merapi eruption-prone areas was taught thematically in elementary schools. This SETS thematic learning facilitated teachers in explaining disasters comprehensively from science, environment, technology and society perspective, and was integrated with the local wisdom. Thus, the students could get better, comprehensive and deep knowledge about disasters especially Mount Merapi eruption.

This disaster learning was designed by combining the science, technological, and social elements. The science elements serve to equip students with sufficient knowledge about natural disasters and signs of changes in nature seen from the science perspectives. The science element is then followed by some avoided environment conditions preceding a disaster. On the other side, the technological elements function to inform about technologies employed to detect the occurrence of a disaster so as

to generate the right response and attitude. In addition, the social elements serve as a role in providing students knowledge about the adaptation in pre-, while-, and post-disaster.

This disaster learning was implemented among elementary school students having the learning tools consisted of the syllabus, instructional plan, teaching materials, learning method, and evaluation device. The research done by Amri et al. (2017) and Sakurai et al. (2018) gave a disaster knowledge in a tsunami-prone area, resulting in resilient students toward tsunami. The difference between this learning and similar learning in the previous research lied in the grades to which the learning was applied. The prior research applied the disaster learning to elementary students grade IV, V, and VI, also, to junior high school students grade VII, VIII, and IX. In addition, the learning focused on how the teachers taught the integrated learning materials. Therefore, this research complements the prior study since it did not only emphasize on the way the teachers taught, but also the learning outcomes in terms of the students' knowledge, attitude, and disaster mitigation practice. In other words, the learning had broader domain knowledge. Also, the disaster learning was implemented only for V grade elementary students in accordance with the latest curriculum, resulting in a better application. Besides, the disaster learning in this research pointed to only a disaster which hea-

ded to specific, detailed, and in-depth learning materials.

METHODS

This research was an experimental research having the research sample picked using the purposive sampling technique. This technique was adopted in accordance with the research purpose of implementing such learning in a specific area, particularly in disaster-prone areas of Mount Merapi eruption. The research sample was the fifth-grade students in three elementary schools located in the red zone (obliged to evacuate during the disaster) namely SD Negeri Kaliurang 1, SD Negeri Kaliurang 2 and SD Negeri Ngablak situated in Sumbing District Magelang Regency. In addition to those three primary schools, this study also involved one elementary school functioning as a control group, namely SD Negeri Sudimoro 1 which is also located in the same area. Therefore, the schools have the same characteristics of students, environment, potential and vulnerability level to the Mount Merapi eruption. This research was conducted in the Odd Semester, Academic Year of 2017/2018 from August to November 2017. The data types, data collection techniques, instruments, and data analysis techniques employed in this study are presented in Table 1.

Table 1. The Data Types, Techniques, and Data Collection Instruments

Data Types	Data Collection Techniques	Data Collection Instruments	Data Analysis Techniques
Knowledge	Test	Test questions	<i>t-test sampel related</i> <i>N-gain</i>
Attitude	Questionnaire	Questionnaire sheets	<i>N-gain</i>
Mitigation practice	Observation	Observation sheets	Descriptive Percentage

RESULTS AND DISCUSSION

The SETS thematic learning integrated with local wisdom was arranged based on the theory of constructivism and behaviorism. Both kinds were the basis for the development of the SETS thematic learning integrated with local wisdom. These were the rudimentary theories in preparing lesson plans and materials related to cognitive aspects. By merging these two theories, the students having the intention and determination to learn something deeply would be really assisted since they were given detailed in-

formation and urged to practice the knowledge obtained. Hopefully, they could understand all the materials provided.

The learning activities of the Science, Environment, Technology and Society (SETS) thematic learning integrated with local wisdom focussed on a prevention and mitigation simulation when no disaster happened, which included in non-structural mitigation efforts. The stages of SETS thematic learning activities integrated with local wisdom can be seen in Figure 1.

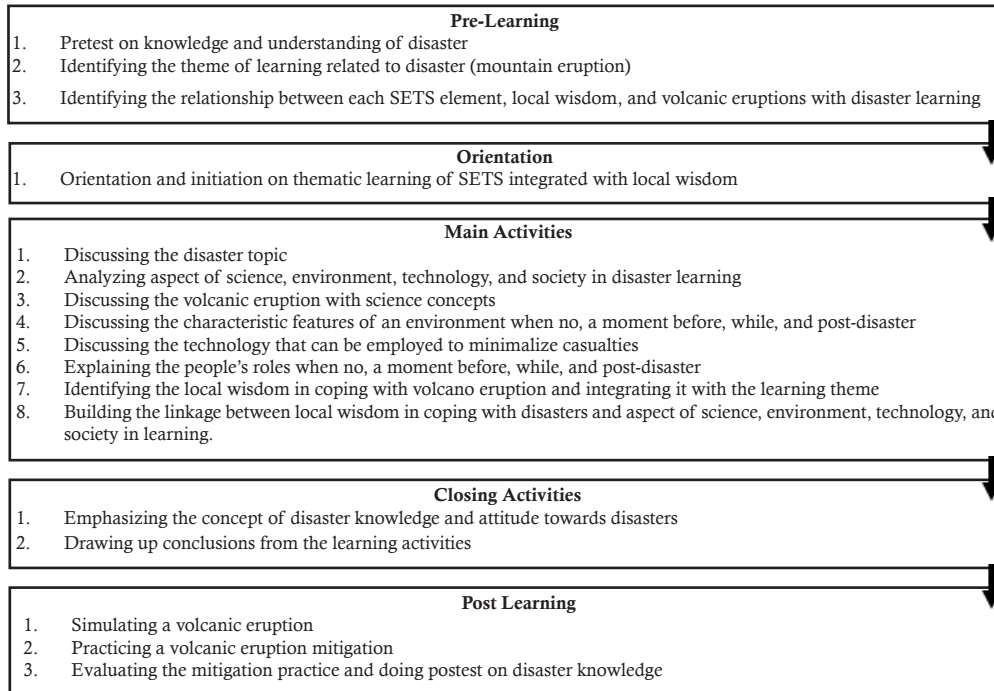


Figure 1. The learning activities of SETS thematic learning integrated with local wisdom

Figure 1 tells that The SETS thematic learning integrated with local wisdom belonged to a volcano eruption mitigation effort. The disaster mitigation itself means a series of efforts to reduce disaster risks in the form of physical development, awareness development, and coping capacity improvement (Hemstock et al., 2017). Disaster mitigation consisted of two kinds of structural mitigation including development and disaster management on the physical aspect and non-structural disaster mitigation in the form of awareness and knowledge to improve people's co-

ping capacity. The non-structural disaster mitigation consisted of counseling, training, and disaster education. In a disaster management cycle, the thematic learning of SETS integrated with local wisdom comprised the prevention and mitigation efforts. These learning activities provided comprehensive knowledge about the prevention and mitigation of volcano eruption that must be understood and controlled by the community in disaster-prone areas. The position of SETS thematic learning integrated with local wisdom in disaster prevention cycles is visible in Figure 2.

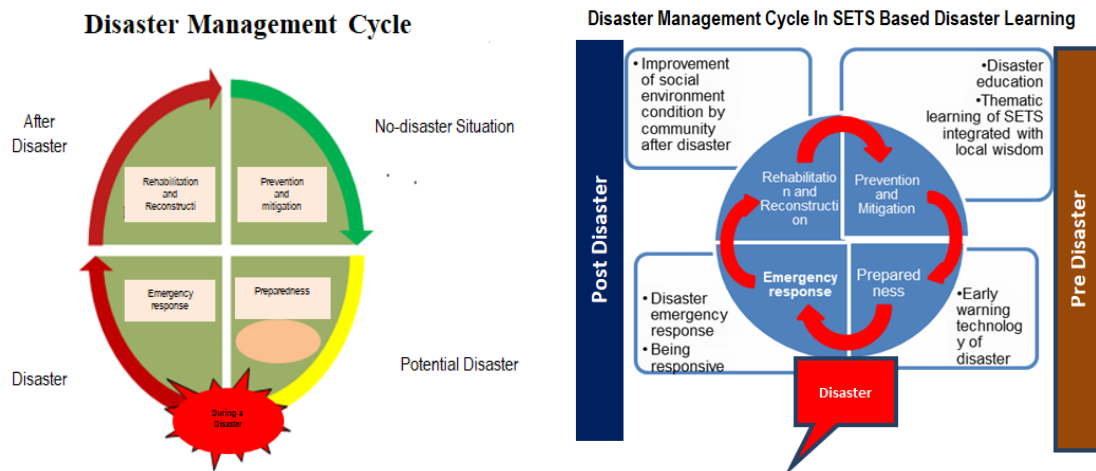


Figure 2. Comparison of the Disaster Management Cycle

Figure 2 tells that the SETS thematic learning integrated with local wisdom acted as a complement to the disaster management cycle. This learning had a role in the formation of disaster concepts and knowledge for the students and communities living in the disaster-prone areas of Mount Merapi eruption. The disaster knowledge was provided at the pre-disaster stage which had an impact on preparedness, emergency response, rehabilitation, and reconstruction. In other words, the provision of disaster knowledge through this learning was a very important role in the formation of a resilient and responsive community to disasters happened in the areas. In Figure 2, it also appears that the disaster management cycles were divided into two; pre-disaster and post-disaster stage. The activity in Figure 2 is a series of activities undertaken to clarify and complete the previous disaster management cycle.

The activities during the pre-disaster started with the delivery of disaster knowledge through the thematic learning of SETS integrated with local wisdom. In these activities, the students were granted the basic disaster knowledge. The knowledge included the mastery of signs found before a disaster happens, the process of a disaster, how to save yourself from a disaster and what to do after a disaster occurs. All activities undertaken were linked to the concept of science, environment, technology, and society including the society's local wisdom in coping with disasters. The second activity was to identify and comprehend the early warning technologies that played a role in increasing knowledge for disaster prevention and mitigation. By mastering the disaster knowledge and mitigation skills, the students would shape their attitude toward disaster preparedness (Chou & Wu, 2014; Ishizuka, 2015; Liu et al., 2016). It appears in Figure 2 that disaster education through learning activities in the pre-disaster stage greatly affected the next activities conducted while and post-disaster. In other words, it was able to cultivate the students' and people's response to a disaster.

Equipped with strong knowledge and emergency response capabilities, it was expected that the students and communities become responsive during and after disasters (Erni & Edi, 2017). The difference between the research by Erni & Edi (2017) and this research was on the knowledge given. The prior study provided knowledge about the flood disaster in the watershed area of Semarang Central

Java, while this research gave disaster knowledge about Merapi eruption to students in the slopes of Mount Merapi, Magelang regency, Central Java. This volcanic disaster knowledge is very important for the students in the area. The provision of knowledge about eruption to the students was divided into three sub-sections of knowledge which were the pre-, while-, and post-disaster. These three stages required a good mastery of disaster knowledge in identifying the disaster signs, providing first aid to disaster casualties and the first thing to do to the environment after a disaster. By completing the cycle of disaster management, it was expected to make the students and society to be able to rehabilitate and reconstruct the environmental and social conditions after the disaster. The provided knowledge to ameliorate preparedness and disaster risk reduction was in line with the Sendai Framework for Disaster Risk Reduction 2015 – 2030 stating that the efforts to diminish the number of disaster victims are all activities aimed at minimizing casualties and damage to assets both with structural and non-structural disaster mitigation. The 2015-2030 frameworks emphasize the disaster risk management and instead of the disaster management. The expected outcomes are targeted disaster risk reduction, prevention of new risks, existing risks reduction and resilience strengthening (Kelman, 2015; Dickinson et al., 2016; Pearson & Pelling, 2015).

The SETS thematic learning classified as non-structural disaster mitigation aiming to equip elementary school students with disaster knowledge. It was implemented in three elementary schools in the disaster-prone areas of Mount Merapi eruption. The results showed that there were differences in the mastery of knowledge between the students taught using the SETS thematic learning integrated with local wisdom, and students who learn using another learning method. The t-test result of the pretest and posttest data on students' disaster knowledge from the control class and experimental class intended to find out whether the learning applied to the experimental class has been proven to be more effective than the conventional learning. The data analysis used the paired samples t-test comparison on SPSS version 20. The t-test data summary of the pretest and posttest on the students' ignorance from the control class and experiment class is presented in Table 2.

Table 2. The Summary Test-t Pre-test and Posttest Knowledge of Students in the Experimental Class and Control Class

Class	T _{count}	df	Sig. (2-tailed)	Information
Pretest-Posttest Ex-periment Class	-80,891	37	0,000	Sig. (2-tailed)<0,05= significant
Pretest-Posttest Con-trol Class	-1,604	37	0,117	Sig. (2-tailed)>0,05= not significant

Table 2 shows that the t-test analysis of pretest and posttest data of experimental class knowledge scores obtained -80.891 with df = 37 and Sig. (2-tailed) = 0,000. Sig value. (2-tailed) was smaller than the 0.05 significance level (0.000 <0.05). The results of t-test showed that there were differences and significant increase of disaster knowledge from the experimental class before and after treatment by applying the SETS thematic learning integrated with local wisdom. Based on the t-test analysis of pretest and posttest data, the value of disaster control class knowledge obtained the t count equal to

-1,604 with df = 37 and Sig. (2-tailed) = 0.117. Sig value. (2-tailed) was greater than the significance level of 0.05 (0.117 > 0.05). Thus, the t-test results indicated no significant difference or increase in disaster knowledge of the control class.

In addition to the differences, the implementation SETS thematic learning integrated with local wisdom could increase the mastery of disaster knowledge before and after learning. The increasing of the students' disaster knowledge mastery in all three elementary schools appears in Table 3.

Table 3. Disaster Knowledge Mastery

School Names	Pre Test	Post Test	Gain	N gain	Category
SD Negeri Kaliurang 2	51,35	72,25	20,90	0,42	Medium
SD Negeri Kaliurang 1	53,57	72,75	19,18	0,41	Medium
SD Negeri Ngablak	51,76	74,32	22,56	0,46	Medium
SD Negeri Sudimoro 1	52,32	66,25	13,93	0,29	Low

Table 3 indicates that there was an increase of the students' disaster knowledge mastery in those three primary schools (SD Kaliurang 1, SD Kaliurang 2 and SD Ngablak) which applied the thematic learning of SETS integrated with local wisdom and another primary school (SD Sudimoro 1) that adopted another method. All schools that taught disaster materials to their students either using thematic learning of SETS or other method had their students' knowledge increased. The increasing can be seen from the N-gain scores obtained by each elementary school. The highest increase occurred in the State Ele-

mentary School Ngablak with 0.46 which belonged to the medium category, the next two schools teaching disaster knowledge by implementing the thematic learning of SETS integrated local wisdom also experienced an increase in the middle level. Meanwhile, the other school which was a control school had a gain score of 0.29 which included the low category. The disaster knowledge was divided into three sub-knowledge of pre, while, and disaster. The percentage of students who mastered disaster knowledge in all three sub-knowledges of each elementary school emerges in Figure 3.

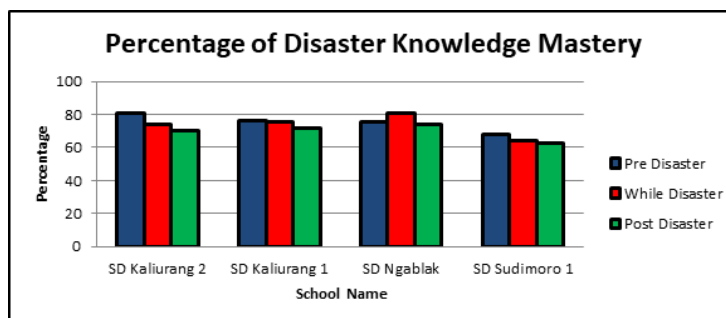


Figure 3. The Percentage of Students who Mastered Disaster Knowledge after Learning Activities

Figure 3 tells that the percentages of the students' disaster knowledge mastery in the three primary schools applying the SETS thematic learning integrated with local wisdom were in 'good' category, with the average percentages ranging from $70 \geq X \leq 85$. Of the three sub-knowledges, the highest was on the pre-disaster knowledge in Elementary School Kaliurang 2 achieving 80.50 percent. Furthermore, the highest knowledge mastery in SD Ngablak was on while-disaster knowledge achieving 80.45 percent. Also, the highest knowledge mastery of SD Kaliurang 1 was on pre-disaster knowledge which was 76,52 percent. On the other side, SD Sudimoro 1 (the control group) had the three sub-knowledges in the medium category ranging from $55 \geq X \leq 70$.

The difference in knowledge mastery was caused by the implementation of the SETS thematic learning integrated with local wisdom. Appropriate treatment and the provision of knowledge specifically delivered in accordance with the regions' characters and community could increase the students' understanding significantly (Andreastuti et al., 2017; Manning & Kushma, 2016; Warsini et al., 2015).

Along with the increasing of the students' disaster knowledge mastery, the SETS thematic learning could further change the students' attitudes and views toward disaster. This research also measured the students' attitudes before and after learning. The students' attitudes toward disaster in the four primary schools rise in Table 4.

Table 4. Improvement of the Students' Attitudes toward Merapi Eruption

School Names	Before learning	After learning	Gain	N gain	Category
SD Negeri Kaliurang 2	48,35	87,25	38,90	0,75	High
SD Negeri Kaliurang 1	52,58	88,75	36,17	0,72	High
SD Negeri Ngablak	47,86	88,32	40,46	0,77	High
SD Negeri Sudimoro 1	51,35	78,25	26,90	0,55	Medium

Table 4 shows that there was an increase on the students' attitude toward disaster in elementary school students who experienced the SETS thematic learning integrated with local wisdom, while the students in control school who were taught using different method also experienced attitude improvement but only in 'medium' category. This difference in attitude enhancement was caused by the integration of with local wisdom in the learning resulting in a more receptive student. Conceptual, real-time, and adaptable disaster knowledge was able to change the students' and community's attitudes toward disasters (Lin et al., 2017; David Strang, 2014; Gonzalez et al., 2010).

The students' attitudes toward disaster urgently need improvement as it could change the paradigm within students. All this time, the students believed that disasters are unpredictable natural events so that they have no preparation and the only thing to do is evacuating, while it is not appropriate to evacuate people without considering the region and disaster characters. Hereditarily, the students and community assume that the main signs of eruption are the emergence of white clouds from the peak of the mountain,

the loud voice from the inside of earth and animals' movement from the forest on the slopes of the mountain. However, animals like tigers, monkeys, lions, and deer are rarely found on the slopes of Mount Merapi recently. Thus, people could not use the old paradigms any longer. Such attitudes should be immediately changed in accordance with the conditions of the region along with technological advances. We have installed a variety of technology-based advanced equipment that serves as a sign of danger or disaster alarm. In addition, there are warnings from volcanic activity monitoring officers who always provide updated information related to volcanic activity. With this in mind, people's old attitudes have to be changed. Therefore, if there is a warning alert or there has been a warning from the volcanic activity monitoring officers to immediately move away from danger areas and flee to safer places, the people would obey it.

The improvement of students' attitudes toward disasters was influenced by both better knowledge acquisition and the SETS thematic learning implementation. The volcanic eruption simulation activities were divided into three stages: pre, while, and post-disaster simulation.

The simulation activities served to complement students' understanding of the concept of natural disasters and their mitigation efforts in real environmental conditions. The students were situated as they were facing a Merapi eruption. In these activities, students were required to be responsive and alerted to the changes in the surrounding environment before, while, and post-disaster. Therefore, these activities could improve and stabilize their disaster knowledge, improve and change their attitudes toward disasters, and develop their mastery and ability on disaster mitigation.

Disaster simulation had the main objective to enable the students to cope with the basic competencies of eruption mitigation. There were

five competencies that students need to master through disaster mitigation practices. The five competencies were 1) finding and showing the volcanic distribution, 2) identifying the signs before the eruption, 3) finding and showing the volcanic hazard map, 4) being responsive during the eruption, and 5) skillfully showing the evacuation path to a safer place. The five competencies were measured in this research by observing the students' ability in conducting activities according to the indicators. The observation results of the students' activities based on the indicators of eruption mitigation during the simulation activities appear in Figure 4.

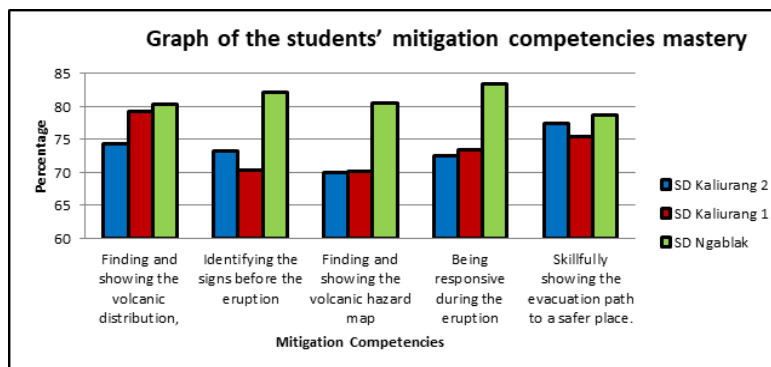


Figure 4. The Percentage of Mitigation Competence Mastery

The mastery of knowledge, fast response, and mastery of disaster mitigation competencies were required in coping with the real disasters. Figure 4 shows that the mastery of disaster mitigation competencies of the volcanic eruption in three schools applying the SETS thematic learning integrated with local wisdom was in 'good' category. The schools had more than 70 percent of the students mastered all disaster mitigation indicators and belonged to good category ($70 \geq X \leq 85$). This enabled the students to act quickly and responsively in real disaster situations. Better mastery of knowledge, attitudes, and mitigation competencies also resulted in a resilient and alerted community for disasters. (Amri et al., 2017).

The enhancement of disaster knowledge, attitudes, and mitigation skill of the students occurred due to the implementation of the SETS thematic learning. In the SETS thematic learning integrated with local wisdom was designed specifically to study the theme of volcanic disaster by connecting the elements of science, environment, technology, and society. These elements served to equip the students with sufficient knowledge about the natural disasters and scientific signs of

natural changes. Furthermore, the environmental elements had a role to show the students the tormented environmental conditions at any time a disaster occurs. The technology elements were given to the students to provide information about the technologies used to detect the occurrence of a disaster so as to reduce its risk. Moreover, the social elements were to educate the students on how to respond to post-, while-, and post-disaster. In addition to these four elements, this learning also integrated local wisdom as part of learning. This local wisdom was to facilitate the reconstruction of disaster knowledge among the students and community. Local wisdom acted as a bridge between the science concepts with the hereditary concepts related to disaster events. Through this learning activity, the students have gained comprehensive knowledge related to disasters and improved their disaster knowledge which they have been practicing for generations so far. In sum, the SETS thematic learning integrated with local wisdom has been proven to assist the students gained better, comprehensive and deeper knowledge about disaster especially Mount Merapi eruption.

CONCLUSION

The implementation of SETS thematic learning integrated with local wisdom was able to reconstruct and increase the knowledge of disaster seen from the N-gain score obtained by each elementary school. The highest increase occurred in SD Ngablak which obtained a score of 0.46 and belonged to the medium category. The students' attitudes toward disaster increased in the elementary schools implementing the SETS thematic learning integrated with local wisdom, having the highest gain score of 0.77. All disaster mitigation indicators were successfully mastered by more than 70 percent of students in the good category ($70 \geq X \leq 85$) in all three primary schools that adopted the thematic learning of SETS integrated with local wisdom.

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**THE MODEL OF EDUCATIONAL RECONSTRUCTION: STUDENTS' CONCEPTUAL KNOWLEDGE ON SOLID STATE CHEMISTRY DOMAIN****E. Nursa'adah^{*1,2}, Liliasari², A. Mudzakir³, H. D. Barke⁴**¹Departement Chemistry Education, Universitas Sultan AgengTirtayasa, Indonesia²Departement Science Education, Postgraduated Studies Universitas Pendidikan Indonesia, Indonesia³Department of Chemistry Education, Universitas Pendidikan Indonesia, Indonesia⁴Institut für Didaktik der Chemie, Universität Münster, Germany**DOI: 10.15294/jpii.v7i2.14297**Accepted: March 2nd, 2018. Approved: May 23rd, 2018. Published: June 30th, 2018**ABSTRACT**

Solid state chemistry (SSC) concept is abstract yet makes it difficult for students. Considering students' and scientist conception in designing a learning sequence, it is important to make scientific knowledge to be comprehensible for students. Model of Educational Reconstruction (MER) was adopted to define learning in order to develop students' Conceptual Knowledge (CK) of the SSC concept. A sequence of learning activities was designed based on the MER. The purpose of this study was to examine the use of MER in developing students' CK. One group pre- and post-test experimental design was employed in this study. CK on SSC structured essay test consisting of 26 items were developed to measure students' CK before and after their involvement in learning. Paired sample t-tests were employed and the results showed significant differences in the overall domain-knowledge ($p < .001$). In detail, students' CK categorized into complete (C), incomplete (IC), misconception (M), incorrect (I), and no answer (NA). After the intervention, the number of students that answered correctly increased (57,4% complete and 21% incomplete). This study showed that MER was an effective learning design to develop students' conceptual knowledge of chemistry concepts.

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Keywords: Model of Educational Reconstruction, Conceptual Knowledge, Solid State Chemistry

INTRODUCTION

The abstract characteristic of solid state chemistry concept closely relates to real phenomena. This topic focuses on structure-property relationships and allows students to make connections between science and daily life. In order to enhance students' knowledge of structure-property relationships, chemical structures and chemical bondings- metallic, ionic and covalent-concepts should be well comprehended by students. However, most of these concepts are at the abstract molecular level in which students usually

find it difficult to comprehend (Bergqvist et al., 2013; Croft & de Berg, 2014; Dhindsa & Treagust, 2014; Nimmermark et al., 2016).

There are many researchers and practitioners of chemistry education who study how to teach SSC concepts. The learning strategies used were: first, structure description using physics model such as plan view, 3D-picture, and analog (Battle et al., 2010; Cushman & Linford, 2015; Eymur & Geban, 2017; Karacop & Doymus, 2013; Pinto, 2012), and second, the use of software (Bennett & Rabe, 2012; Ganasen & Karpudewan, 2017; Linenberger & Bretz, 2012). Unfortunately, researchers still reported about students' misconceptions on chemical bonding as a base of SSC concept (Bergqvist & Rundgren, 2017;

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Bergqvist et al., 2016; Pérez et al., 2017; Sen & Yilmaz, 2017).

Students bring along their own conceptions to class. This should be a concern for teachers in considering instructional design. A teacher would find it difficult to teach a particular concept if misconceptions exist in the initial concept of students (Barke et al., 2009). Therefore, learning must be a bridge between students' and the scientist conception.

Model of Educational Reconstruction (MER) is a way to prepare contextual learning considering students' and scientists' concept (Duit et al., 2012). Learning reconstructions were done through three relevant phases: (1) analyzing the science content; (2) investigation on student conception; and (3) developing learning sequences (Duit et al., 2012; Niebert & Gropengiesser, 2013; Sam, 2017).

Considering student conception of learning sequences could promote a highly significant development of conceptual knowledge (Reinfried et al., 2015; Sam et al., 2015). Regarding the importance of considering students and scientists' concept in designing an SSC learning concept and many benefits of the MER-based interventions, the purpose of this study is to examine the use of MER in developing the students' conceptual knowledge toward scientist conception.

METHODS

This study was considered a one group pre-test and post-test pre-experimental design. 33 pre-service chemistry teachers in one of the state universities in Banten have participated in this research. The instruments of this study were the pre-test and post-test of on conceptual knowledge of SSC (26 essay structured questions).

There are three domain-knowledges of solid state chemistry concept that developed in this study: (1) metallic crystal and alloy structures; (2) covalent bonding and semiconductor network; and (3) ionic crystal structure and bonding. More than two questions examined each domain (Table 1). The instrument was validated by five experts in chemistry education and Content Validity Ratio (CVR). The CVR value was .99 (acceptable (Wilson et al., 2012)). Cronbach's alpha coefficient was computed to measure the reliability of questions. The coefficient was 0.77 (acceptable (Glynn et al., 2011)). The primary data were students' responses to the tests of conceptual knowledge. Students' answers to each concept were also scored (Table 1).

Table 1. Question Criteria

Concepts	Domain knowledge	Question number	Score
Metallic bonding related to the melting point	Metallic crystal	1Aa	0-3
Metallic bonding model		1Ab	0-3
Metallic structure related to % occupancy		1B	0-3
Metallic structure related to density		1C	0-2
Metallic structure related to ductility	Alloy	1D	0-2
The material conductivity and band theory		2B	0-2
Total			13
Alloy criteria		1Fb	0-2
Type Alloy structure		1Eb	0-1
Type of an alloy		1Ea, 1Fa	0-3
Total			6
The conductivity of material	Covalent crystal	2Aa	0-3
The material conductive		2Ab	0-4
Covalent network structure		4A	0-2
Covalent network properties		4B	0-3
Polymer conductive		5A	0-2
Polymer conductive structure		5B	0-2
Total			16
Type of a semiconductor	Semiconductor	2Ca, 2Cc	0-4
The conductivity of extrinsic semiconductor model		2Cb	0-2
Conductivity process in semiconductor		2Da	0-1

Semiconductor bonding model		2Db	0-1
		Total	8
Ionic structure	Ionic crystal	3A	0-2
Covalent bonding and ionic bonding		3Ba	0-3
Ionic crystal properties		3Bb	0-1
Ionic versus metallic crystal properties		3C	0-2
Ionic crystal defect properties		3D	0-2
		Total	10

To analyze the students' conceptual knowledge before and after the intervention, their answers in the pre-test and post-test were categorized into five categories (complete, incomplete, misconception, incorrect, and no answer).

The total score for each concept was different; it depended on the complexity of conceptual knowledge required to answer the questions. For example, the scoring guide for question number 1Aa are: (1) Complete, for students who answered in accordance with scientists conception, who mastered basic knowledge, and could relate their knowledge to explain the phenomena or question: score 3, also students who completely described the process of metallic bonding, comparing the parameter of metallic bonding in sodium, magnesium, and aluminum, and explaining the reason of the increasing melting point from sodium to aluminum; (2) Incomplete: score 1-2, for the students who knew the basic concept but could not connect it to a complete explanation; (3) Misconception: score 0, for students indicating misconceptions; (4) Incorrect: score 0, for students who were incorrectly or irrelevantly ans-

wering the questions; and (5) No answer: score 0, for students who did not provide answers on their answer sheets.

CK scoring was done for the pre-test and post-test. Paired sample t-tests adopted to analyze the differences between the pre-test and post-test results in students' CK. A test of hypotheses with p -value $< .05$ was considered as significant. The scores of each knowledge domain then have been converted to the n -gain to see the increasing domain-knowledge.

RESULTS AND DISCUSSION

Learning Design Based on the MER

MER considers students' and scientist conception in designing a learning sequence in order to bring student conception toward scientist conception. Learning sequences were designed based on MER. The conceptions that scientists and students have on SSC concepts were presented in the analysis section of selected data.

Scientist conception analysis was done in order to define and determine: 1) theories and conceptions; 2) function and meaning of science conception; 3) position of theories and concepts; and 4) field of applications. Inorganic books (Housecroft & Sharpe 2012; Miessler et al, 2014) were analyzed to determine scientist conception. The analysis of student conceptions was to clarify a scientific concept in students' perspectives. Therefore, the students were expected to translate their conceptions of SSC concept into a concept map and interviews.

Based on the characteristics of SSC, the topic was discussed based on the relationship among structures, properties, and applications. Regarding the criteria, the scientists' and student conceptions about SSC concepts-metallic, ionic, and covalent network crystal- are described in Table 2.

Table 2. The Student and Scientist Conception about SSC

No	Concept	Scientist Conception	Student Conception
1	Metallic Crystal structure	a. Generally, metals are known by students as a solid material at room temperature (25 °C) except mercury which is liquid, most have a silvery shine, are malleable and ductile, are good conductors of heat and electricity. The ability to conduct electricity in metals is explained by the "sea electron" model. Besides, the model can be used to predict the conductivity of polymers.	a. Valence electrons are bonded to metal atoms b. Friction between two metallic atoms causes valence electrons to form "sea electrons" c. The "sea electron" model differs from the metallic bonding d. Metal conduct electricity because of the friction between two metallic atoms to produce valence band

		<p>b. Electric conductivity of conductors, semiconductors, and insulators are described using band theory (valence band and conduction band). Based on the band theory, we could explain the type of semiconductors. Pure materials that have semiconductor properties are called intrinsic semiconductor. Other elements that are not semiconductor purely can be modified by adding elements to make doped semiconductor, they are called extrinsic semiconductor (n-type and p-type).</p> <p>c. One of the applications of the extrinsic semiconductor is the diode.</p> <p>d. Other properties of metals: malleable and ductile. To determine these properties, the analysis of metallic structure such as FCC, HCP, BCC, and SC needs to be discussed.</p>	
2	Covalent Network	<p>a. Covalent network topic in this study is limited to diamond and graphite. Both are arranged by the same constituent components: carbon atoms.</p> <p>b. The structure differences cause them to have different optical, electronic, and mechanical properties.</p> <p>c. The invention of new applications of graphene provides challenges, opportunities and becomes an interesting study. Graphene is a layer of graphite, graphene properties of having electrical conductivity stronger than graphite are easily explained by understanding the bonds and structures of graphite and graphene.</p>	<p>a. Intra-molecular forces are stronger than others and there are electron shared</p> <p>b. Covalent bonds are formed by sharing pairs of electron and its strong bonding characters, because there are sigma and pi bonding</p>
3	Ionic Crystal structure	<p>a. Ionic solid conductivity differs from metals which can conduct electricity in a solid state. Salts conduct electricity in liquid or solution phase.</p> <p>b. Ionic solids are hard but very brittle – forces differ from the metal. Those properties are explained by different chemical bonding.</p> <p>c. In addition, the influence of covalent characters in ionic compounds also affects properties of ionic compounds such as melting point and solubility.</p>	<p>a. There are cations and anions in addition to Na atoms which have not become cations yet</p> <p>b. There are electrostatic forces, electron handover takes place</p> <p>c. There is an attraction between cation and anion and there is a force between positive and negative molecules</p> <p>d. Ionic solid conduct an electric current due to the electrostatic forces that cause free electrons to move</p>

Table 2 shows that some students experienced misconceptions on the SSC concept, resulting in difficulties to explain properties of the material. Our task is to change their conception to the scientific conception. Scientists and student conceptions are considered to de-

sign learning sequences. Prior to knowledge of students about the SSC, the concept was the basis for designing interventions, media, experiments, and instrument test. Each intervention aimed to develop students' conceptual knowledge (Table 3).

Table 3. Learning Design Based on The MER

Concept	Scientist conception	Student conception	Reconstruction			
			Learning Design	Media	Experiment	Evaluation
Metallic bonding	Metallic bond explains the strong attraction of closely packed positive metal ions and a "sea" of delocalized electrons	a. Valence electrons are bonded to metal atoms b. Friction between two metallic atoms causes the valence electrons to form "sea electron" c. The "sea of electron" model differs from the metallic bonding	a. Analyzing metallic properties b. Illustrating the "sea of electron" model as metal bonding c. Predicting metallic properties based on structures	"sea of electron" model	-	Analyzing metallic bonding in a metal to predict its properties
Metal Conductivity	The conductivity of metals is due to the presence of delocalized electrons	Metals can conduct electricity because of the friction between two metal atoms to produce the valence band	a. Analyzing "sea of electron" model to explain electric conductivity of metals b. Band theory model to explain why a material can act as a conductor, an insulator, and a semiconductor	"sea of electron" model, Band theory model	Designing experiment to test conductivity of material	Predicting a certain conductivity of the material
Ionic Bonding and structure	Ionic bonding is a type of chemical bond that involves the electrostatic attraction between oppositely charged ions	a. There are cations and anions besides Na atoms that have not yet become cations b. There is an electrostatic force and an electron handover takes place c. There is an attraction between cations and anions and there is a force between positive and negative molecules	a. Analyzing the coulomb force that occurs in ionic compounds b. Describing ionic bonding (considering the size and charge of ions) c. Analyzing and differentiating ionic bonding d. Analyzing ionic crystal structure and discussing models	Ionic crystal structures and models	-	Analyzing ionic bonding in an ionic compound to predict its properties

Table 3 shows that students started learning from analyzing a daily life context, formulating questions related to the context, making hypotheses, planning laboratory activities to test the hypotheses, investigating laboratory phenomena, and using the theory to predict phenomena. The students were asked to evaluate the theories and predictions in more complex contexts.

In those activities, the mental model about the chemical structure like packing crystal structure and molecules is the big goal in order to make students connecting the structure

to properties, for reaching this goal we need media to model chemical structures (physics and animation) to teach them successfully.

The Student Conception on the SSC

The patterns of student conceptions on each domain-knowledge before and after the MER-based learning categorized into 1) complete (C), 2) incomplete (IC), 3) misconception (M), 4) incorrect (I), and 5) not knowing concepts, not providing answers (N). The data are presented in percent form to know the results of students in each category (Table 4).

Table 4. Categories of the Students' CK on SSC Concepts

Domain Knowledge	Student Conceptions									
	Before Intervention (%)					After Intervention (%)				
	C	IC	M	W	N	C	IC	M	W	N
Metallic Crystal	17	22	14	22	24	48	22	11	12	6
Alloy	0	33	0	27	39	61	24	0	12	3
Covalent Network	1	11	6	7	75	71	10	0	9	10
Semiconductor	17	11	0	8	63	58	21	0	12	8
Ionic Crystal	6	4	7	24	60	49	28	4	14	4

Table 4 indicates that the learning design based on MER improved student conceptions almost on every topic that built domain-knowledge.

The percentages of students in complete and incomplete categories increased after the intervention. In contrast, the percentage of students with misconceptions, wrong, and no answer category decreased.

Solid state chemistry contains many abstract concepts such as chemical bonding and structure, molecular and crystal structure. It requires students to think at submicroscopic level. Unfortunately, most of the students at several educational levels find big difficulties. They are low in proficiency level to visualize structures and applications to chemical phenomena, they merely focus on memorizing submicroscopic and symbolic representation. So they cannot well imagine the process and structure of the phenomena and show misconceptions (Adadan, 2014; Adesoji & Omilani, 2012; Barke et al., 2009; Hand & Choi, 2010; Linenberger & Bretz, 2012; Luxford & Bretz, 2014; Madden et al., 2011; Ramnarain & Joseph, 2012; Stojanovska et al., 2017).

Considering students and scientist conception in designing learning topics gave students opportunities to examine and revisit their own

conception, revise them and build scientific knowledge (Niebert & Gropengiesser, 2013; Sam et al., 2016). In addition, all media of molecular modeling or crystal structures are designed based on students' need. Therefore, it would make students easily recognize those models.

For example, before the intervention, most of the students answered incorrectly even were showing misconceptions about the differences in diamond and graphite properties. Both have very different properties: they are constituted of the same composition, carbon atoms – but the arrangements of C atoms are different. After the intervention, the students could answer correctly that both graphite and diamond have different chemical structures. A strong covalent bond makes them both have a high melting point. In graphite, each carbon atom bonds to three other carbon atoms, while in diamond one C atom bonds to four other C atoms. Therefore, there are free electrons in graphite. These free electrons cause graphite to conduct electricity while diamonds do not. The students described diamond and graphite structures well.

Almost all domain knowledge of students has increased. Unfortunately, in the domain of metallic and ionic crystal structures, misconceptions were found on some students. However, the

numbers decreased after the intervention.

In the metallic crystal domain, some students still consider that the "sea electrons" model is different from the metal bonding model. This understanding had an impact on determining the physical properties of metals such as melting point. Six percent of the students in the post-test assumed that the increased melting point of sodium, magnesium, and aluminum metal were due to the distance of atoms. The periodic table shows that the nuclei and the last electron are far separated so that they do not relate to the ocean model of electrons as visualized in the learning process. Before the intervention, 27% of the students considered that the increased melting point from sodium to aluminum metal was due to intermolecular forces that make up the metal.

Some similar misconceptions occurred among the students who assumed that there is no bonding between metal atoms. They thought that metals are the electric conductor since metal atoms are conducting electricity. This indicates that the students had difficulties in distinguishing atoms and metal ions in metal structures (Barke et al., 2009; Bergqvist et al., 2013). Some researchers found that all the misconception occurred as students are lack to attribute the macro phenomena to the sub-micron level (Pérez et al., 2017). On the other hand, teachers may contribute to this misconception as they are not aware of the terms they use (Bergqvist & Rundgren, 2016). Normally, experts easily move from macro to particulate representation, but it is hard for students.

Explanations and visualizations of metal bonds were presented to help the students understand the bonds occurred in the metal and relate it to the physical properties of the metal including the melting point. Unfortunately, not all students were able to connect the structure and properties. Understanding the structure and relating it to nature is a challenge for the students. This is in line with the results of the study conducted by (Cheng & Oon, 2016; Pérez et al., 2017).

Misconceptions on the concept of metal structure and bonding also led 9 % of students to assume that metal bonds are stronger than ionic bonds. They applied this misconception to explain the fragility of ionic crystals over metal crystals. They assumed that ionic bonds are weaker than metal bonds. In fact, there are strong bonds that hold ions to stay in position in the crystal lattice. Changing the positions of these ions requires a strong force. If forces are applied to the ionic crystals, ions of the same charge will be closer to each other and the repulsion force will cause a sudden breakup of the crystals. To understand

the connection between structure and properties, the students need a good understanding of chemical bonding. This is in line with Barke (2009).

Chemical bonding topic has been taught since high schools in Indonesia. Simplification of chemical bond concepts in high school causes students to use alternative concepts in the higher education level. This finding is in line with the previous research reported that chemical bonding is a difficult concept and gives many alternative concepts developed by students (Croft & de Berg, 2014; Dhindsa & Treagust, 2014; Nimmermark et al., 2016). The main point in the findings of this domain-knowledge is that the stabilized basic concept among students is important since one of the most important things in inorganic chemistry is the applied concepts.

Another research found that high school teachers always depend on school textbooks (Bergqvist et al., 2013); meanwhile, representation of chemical structures in school textbooks may cause students misconceptions without a scientific explanation from the teacher. There is also a need to fill the gap between researchers and textbook writers because books influence teachers' selection and use of representations for their lessons.

The Students' CK on the SSC Concept Improved Significantly

To identify whether or not there were significant differences between the pre-test and post-test scores, paired sample t-test was performed (Table 5). The results show that the difference between the pre-test and post-test scores in all domain knowledge ($p < .001$) improved significantly.

Table 5. Paired Sample T-Test between Pre-Test and Post-Test of the Students' Domain Knowledge

Domain knowledge	Mean		Std. Dev.		Sig. (2-tailed)
	Pre-test	Post-test	Pre-test	Post-test	
Metallic crystal	2.93	8.12	1.99	2.89	$p < .001$
Alloy	0.82	4.30	1.01	1.75	$p < .001$
Covalent crystal	0.42	8.16	0.80	1.73	$p < .001$
Semiconductor	1.57	4.91	1.73	1.94	$p < .001$
Ionic crystal	0.42	5.37	0.75	2.48	$p < .001$

Table 5 tells that students' domain-knowledge increased and differed significantly in all domain-knowledge before and after interventions based on MER. Those results indicate that MER-based learning improves students' understanding of concepts significantly.

The results show that MER is a powerful strategy to develop student conceptions. This is in line with previous research results. It proves that MER-based learning develops students' conceptual knowledge, in which the knowledge increased significantly toward the scientist conception. It is also stable at a high level for some domains such as chemistry, physics, and geography (Reinfried et al, 2015; Sam et al 2016; Sam et al, 2015).

Barke et al, (2009) thought that students enter the classroom with their own conceptions of matter. Such conceptions can be obtained either from home or school. Unfortunately, not all of their conceptions are in accordance with the scientist conceptions, and even some of them are misconceptions. For instance, when students present questions about the fragility of ionic crystals compared to metallic crystals, they assume that metallic bonding is stronger than ionic bonding. In addition, some students believe that small cation sizes cause the fragility of ionic crystals. If the misconceptions are not detected early, then it would be difficult for teachers to teach other concepts.

The MER learning design focuses on the reconstruction of student conceptions. This helps students to understand the key concepts and to identify relationships between students' and scientist conceptions in order to decrease the gap between those two. Therefore, analyzing student conceptions before determining appropriate instructional designs contributed to conceptual understanding as well as the process of clarifying concepts by students (Sam, 2017).

Mastering the basic concepts clarifies that students are capable of using basic concepts to explain phenomena or properties of the material. In addition, students are able to use basic concepts to predict properties of other material. As an example, students who could predict well the conductivity of material based on the "sea electron" model would impact on their ability to design the steps for making glass and polymer conductive. Students are challenged to conduct glass and conductive polymer experiments. Both substances could be found in many modern applications such as touchscreens on mobile phones.

The Students' CK enhanced the SSC Concepts

To see clearly the increasing of each domain-knowledge, the scores of which then were converted to the n-gain (Figure 1).

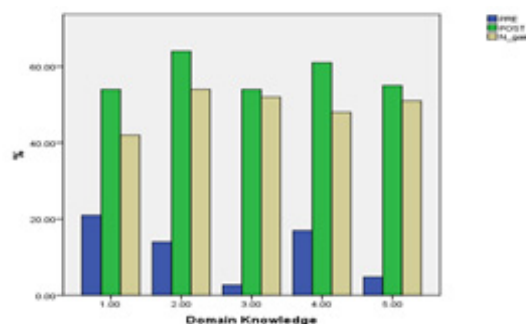


Figure 1. The Average Percentages of the Pre-test, Post-test, and N-gain Scores of Students on Each Domain-Knowledge.

The figure conveys that the percentage of the post-test scores of all domain-knowledge was higher than the pre-test with the middle n-gain category. MER had benefits for classroom learning design. The scientist-student content should be implemented to solve the assumption that knowledge cannot directly be transferred from scientist to students (Niebert & Gropinggiesser, 2013; Sam et al, 2016). The open-ended discussion which posters conceptual knowledge is the best way to build up students the scientific knowledge and solve problems.

Criteria, properties, and structures of metal alloys were examined through group discussion. The discussion gave students the opportunity to get involved in thinking of the relationship between property and application of alloys with their structure. Structure visualizations presented through multimedia helped the students investigate the submicroscopic level. Correctly, most students were able to determine the types of alloys, as well as properly produce metal alloys. During the learning process, the students were very interested in discussing alloys, many of them wanted to create alloys to discover other properties such as color, strength, and conductivity.

Alloys are an application of metallic crystal concepts. Chemical science concepts in high school and basic chemistry courses do not emphasize the content of alloys in learning so that it is new for the students. The chemical content of solid state chemistry is studied in high school through chemical bonding topic. The topic focuses on comparing the process of ionic, metallic, covalent, coordination covalent bonding, and in-

ter-molecular forces with the physical properties of the compounds. The analysis of several RPS in some of Indonesia's University of education also shows that the topic of alloys has not been studied in basic chemistry learning.

Meanwhile, students often find the application of metal alloys in everyday life such as precious metals, sculptures, household utensils, weapons and others. For example, sterling silver is a metal alloy consisting of 93% silver and 7% copper. It is considered as the precious metal. Its mechanical properties are strong and cheap, under than silver at 99% purity. The uniqueness made the students interested in learning other alloy properties such as their questions are: "*How is the electronic property of metal alloys? Is it still the same as its pure metal?; how to explain the alloy structure?; how to produce an alloy?*". This became an opportunity for teachers to invite students to discuss this topic.

The students were able to determine both interstitial and substitution metal alloys. The alloy criteria required to determine alloys such as the size of the atoms, its electron structure, and metallic crystal structure. In this domain, alloys reached the highest n-gain (54 in middle category). This is parallel to the previous research suggesting that group learning with animation or media aid is more effective and provides students opportunities to improve their understanding—even through pleasant discussions between their friends (Eymur & Geban, 2017; Ganasen & Karpudewan, 2017; Karacop & Doymus, 2013). However, discussions and interactions between students and teachers would not occur if the discussed topic is not interesting and challenging for students.

The n-gain in understanding metallic crystals was the lowest (42 in middle category). This knowledge was measured by asking students to explain the reason of boiling and melting point increased of sodium to aluminum metal, different metal hardness between sodium and copper metal, different metal ductility between magnesium and copper metal, and comparing the conductivity of the aluminum metal with beryllium semi-metal. To answer all these problems, students must be able to understand the basic concepts of metallic bonding, metallic crystal structure, and band theory.

To answer the increased melting and boiling points from the sodium to aluminum, students must be able to analyze the metallic bonding in the three metallic types. All three have

metallic bonding, in which the positively charged ions bind to the delocalized valence electrons. From sodium to aluminum, ion charge increases and the number of delocalized valence electrons also. It causes the increasing metallic bonding strength from sodium to aluminum, resulting in high melting and boiling point. This understanding will affect students when they are asked to show metal bonding models of the three metals.

Although solid sodium metal can be cut using a ruler, copper metal should be cut by sharp scissors. The hardness of sodium metal compared to copper metal is explained by the metallic packing factor of metallic structures. Sodium metal adopts a body-centered cubic structure, the number of atoms per unit cell is two (one in the middle, $8 \times 1/8$ at eight corners), and the packing factor is 68%. While copper adopts a face-centered cubic structure, the number of atoms per unit cell is 4 and the packing factor is 74%.

The properties encountered in the case of copper and magnesium, both metals have similar properties in terms of "hardness" so that sharp scissors must be provided to cut metal plates. On the other side, copper metal can be made into sheets, while magnesium metal tends to crumble. Both magnesium and copper adopt a closed packing structure. Magnesium takes up a hexagonal close packing structure whereas copper adopts a cubic closed packing structure. In the case of the cubic closed structured crystal, there are glide planes within the atomic layers in all directions, thus, the mechanical attack can be repelled from many directions through the movement between atomic layers. The elementary cube itself allows the movement of smooth triangular layers in four directions, i.e. perpendicular to the four diagonal spaces. In comparison, the hexagonally closed structured crystal has only one direction of the triangular layer in the hexagonal unit cell.

A band shows a group of molecular orbitals. The energies of the resultant MO are very close together; in other words, there is a band of orbitals. The band occupies the valence electrons known as the valence band, and the empty one is so-called the conduction band. The difference distance between the valence band and conduction band (band gap) in some structures shows the conductors, insulators, and semiconductors material. Valence electrons in the valence band are moving freely in all directions, if the electric current is given then the electrons could move to the conduction band when it is able to pass the energy band gap.

Media, animation, and interesting discussions facilitate the students to see the relationship between structure and properties of metal crystals. However, media or animation is only tools, and observing the relationship between nature and structure requires spatial ability. If such ability is not controlled well by the students, it will result in difficulties. This is in accordance with Barke et al (2009) who stated that spatial ability is more important than simply writing down the structure and equation of chemical reactions.

CONCLUSION

The MER is a powerful strategy that could promote students' development of conceptual knowledge, and keep the knowledge stable. The results show that there were significant differences between the students' conceptual knowledge in all domains (metallic crystal structure, alloy, bonding network, semiconductor and ionic crystal) in the pre-test and post-test scores. This indicates that after the implementation of the MER-based learning in solid state chemistry topic, students' conceptual knowledge was close to scientist conceptions.

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SPATIAL INTELLIGENCE AND STUDENTS' ACHIEVEMENT TO SUPPORT CREATIVITY ON VISUOSPATIAL-BASED LEARNING

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ABSTRACT

This research intended to know how the students' spatial intelligence and achievement supported the creativity of prospective teachers. This study was conducted on the subject of plant anatomy with visuospatial-based learning. The visuospatial-based learning model used in this study is called the wimba learning model. The method of this research was a quantitative /quasi-experiment with the pre- and post-test group design. The population was fourth-semester students in four classes of Biology Education who took Plant Anatomy course in 2017 in a university situated a small town, West Java, Indonesia. The sample of this research was two classes picked using the purposive sampling regarding their homogenous sampling of having the relatively same ability. The treatments for each class was that the use of the deductive and inductive approach. The variables measured were spatial intelligence, students' achievement and creativity of TCIA (Test of Creative Imagery Abilities). The data processing adopting multiple correlation tests with SPSS was to see the relationship between the variables. The results showed that spatial intelligence and students' achievement could support creativity at a moderate level, indicated by the value of $R_{\text{deductive}} = 0,451$ and $R_{\text{inductive}} = 0,474$, $R_{\text{inductive}} > R_{\text{deductive}}$, which meant that the inductive approach was better to support creativity. In conclusion, spatial intelligence and students' achievement could support creativity, especially in the inductive approach. The results of this study could be useful to improve the creativity of prospective biology teachers.

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Keywords: creativity, spatial intelligence, students' achievement, wimba learning model

INTRODUCTION

Facing the era of globalization, we should be ready to produce creative and innovative students. Teachers should plan student-centered learning to foster the spirit of learning, motivation, creativity, initiative, innovation, and independence (Fatimah, 2015). In general, learning process either at school or college based only on cognitive. We have forgotten that our children need to improve other intelligence such as spatial, natural, interpersonal, kinesthetic, mathematical and some others. We also believe that there is a

correlation between intelligence and creativity (Jauk et al., 2013). Some students said that learning plant anatomy is quite boring and difficult to understand; therefore, it is necessary to develop an interesting plant anatomy learning. In fact, studying plant anatomy could develop students' spatial intelligence. Thus, plant anatomy learning should be delivered using a visuospatial-based learning model. The visuospatial-based learning model here is the wimba learning model. This model enables students to be active and independent; also, forces students to make microscopic representation and imagine it in the form of three dimensions (3D) features. As the result, students will have a better understanding of cells, tissu-

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es, and organs phenomena in plants. This is in accordance with Bolotin & Nashon (2012) who stated that spatial intelligence is very important to understand phenomena. In fact, only a few students and a small number of graduate students have the opportunity to develop this skill at an adequate level. Spatial intelligence is one of the intelligence that enables one to visualize information and synthesize data and concepts into visual metrics or images. Ramadas (2009) stated that visual and spatial thinking is an integral part of learning science, which is a simplification of complex natural phenomena expressed in concrete, visual or symbolic models. Visuospatial thinking and concept cannot be separated from the process of imagination that has an impact on creativity. Kell et al (2013) stated that spatial ability has a unique role in the development of creativity. Without spatial intelligence, creative thinking and innovative production are incomplete. Improving spatial ability could be achieved by changing one representation to another, just like turning 2D (dimension) representation features into concrete 3D features. These representational skills include the ability to analyze representation features, convert one representation into another, and generate new representations. This activity intends to explain the usefulness of certain representations and explain the uniqueness of different representations (Stieff et al., 2016). Visuospatial representation activities could improve spatial intelligence (Lazear, 2004). Visuospatial thinking cannot be separated from the imagination process. According to Tabrani (2009) imagination is the process of learning, thinking and creating to form memory and increase knowledge. The Wimba learning model, in addition to increasing students' achievement, also helps students develop spatial or spatial-visual intelligence.

Some researchers stated that poor representational competence is a barrier to learning the STEM. Mathematics, physics, chemistry, and biology lessons are identified as the main disciplines of STEM showing the most successful students of those who have representational competence. Visuospatial representation competence is also important in studying biology, especially microscopic concepts such as bacteria, fungi, cells, tissues, organs, etc. The plant anatomy course learns about the structure and functions (Beck, CB, 2010). Microscopic observation can be used to build the cell, tissue and plant organ from 2D images into 3D designs. In addition to recognizing the 3D form, the learning could

make students easily correlate the form and function of these cells. This process is referred to as mental processes, thought processes, imagination processes that can stimulate brain development to improve spatial ability or spatial intelligence.

The results of Suprpto (2012) showed that the wimba learning model could improve cognitive learning outcomes. A person is said to have good visual-spatial intelligence if s/he could answer cognitive questions easily by remembering the shape of figures (Lazear, 2004). Shepard (1978) stated that spatial imagination and visualization are essential for creativity and discovery. So it is believed that learning anatomy plants with wimba learning model has the opportunity to improve spatial intelligence, students' achievement, and creativity. Generally, school learnings are arranged with the deductive approach. The deductive approach carries out learning from general to specific or usually applied in combination with the teacher-centered learning, while the inductive approach brings learnings from specific to general (Atta, MA., M. Ayaz, Q. Nawaz, 2015). The late approach makes students more attractive in seeking their own information. Thus, it assumes that the inductive approach would further stimulate the brain to improve spatial intelligence, gain knowledge and enhance creativity.

Prior research shows that learning on plant anatomy using the visuospatial model (Wimba model) utilizing play dough media could enhance cognitive learning outcomes on the deductive approach, and result in a better understanding of the inductive approach. (Suprpto, 2012). While the results of Suprpto's research (2016) show that Wimba learning model can improve cognitive development and reasoning, especially proportional, correlational and combinatorial reasoning. The correlational and combinatorial reasoning, which is the ability to correlate and make the combination of several variables, concern with creativity. Hence, these reasoning skills foster one's creativity to find a variety of alternative solutions for life and innovation to make products.

With this in mind, this study intends to identify the roles of visuospatial-based wimba learning model in developing spatial intelligence and students' achievement to support creativity in deductive and inductive approach. Information on the results of this study is important as a reference in implementing effective learning model to improve students' achievement, spatial intelligence, and develop creativity.

METHODS

The research method employed in this research was the quantitative/quasi-experiment with the pre-post test group design. The research population was 4th-semester Biology students in 4 classes of 135 students at a university in small town, West Java, Indonesia. The research sample was two classes having relatively the equal ability, picked with purposive sampling. The learning process was carried out using the deductive and inductive approach. The first class applied the deductive approach and the inductive approach for another.

The deductive approach steps started from 1) theory learning that is a) creating concept map created before learning; b) discussion; c) making tentative hypotheses about learned concepts. The next stage was: 2) the laboratory activity, starting from a) microscopic observation (observation of plant cells microscopically); b) representing the observation results of cells or plant tissues in the form of 2D images; c) designing cell or plant tissue images in 3D; d) creating the 3D using 3DsMax software; e) discussing the practical results; f) confirmation. On the other side, the learning process Wimba learning process with the inductive approach began with 1) laboratory work and followed by 2) theories (figure 1).

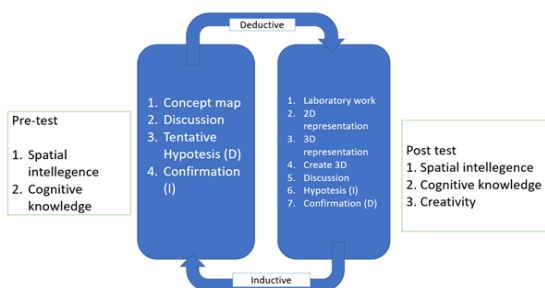


Figure 1. The Wimba Learning Steps with Deductive (D) and Inductive (I) Approach

The research instrument for the measurement of the students' achievement was the multiple choice test of on plant tissue and organ material, and the spatial intelligence was measured by adopting the spatial intelligence test based on Thorndike & Lohman (1990) while the creativity was measured by employing the Test of Creativity Imagery Abilities or TCIA (Jankowska and M. Karwowski, 2015). Furthermore, the learning outcomes were processed using the N-Gain formula of Hake (1998).

To see the correlation between spatial intelligence and students' achievement on creativity with Wimba learning model, the test of students' achievement was done before and after research,

while the test for spatial intelligence and creativity was carried out after learning. The data were proceeded using correlation test (multivariate) on SPSS (Fraenkel and Wallen, 2009).

RESULTS AND DISCUSSION

The research results of wimba learning model with deductive approach present that the average creativity of TCIA = 10.94 and 2.51 of the deviation standard. Whereas the learning results (n-Gain) = 0.47 which belonged to the moderate category and the standard deviation of 0,16. In addition, the spatial intelligence = 11.91 and the standard deviation of 2,275 (Table 1).

Table 1. The Average Results of Spatial Intelligence and Learning Outcomes on Deductive and Inductive Approaches (n-34)

	Descriptive Statistics			
	Deductive		Inductive	
	Mean	SD	Mean	SD
Spatial intelligence	11,91	2,275	8,26	3,93
Students' achievement	0,467	0,165	0,52	0,14
Creativity	10,94	2,51	12,82	1,91

The computation results of correlation test of spatial intelligence and students' achievement toward creativity, simultaneously state that there was a significant relation between spatial intelligence and learning result toward creativity. The correlation coefficient (R) of 0.451 shows the category of medium relations and the coefficient of determination (r) of 0.203 or 20.3% at a significance level of $0.030 < 0.05$.

In addition, only spatial intelligence had a significant relationship with creativity at the sig. level of $0.011 < 0.05$. The regression equation was $Y = 6,950 - 3,146 X_1 + 0,489 X_2$.

The research results of wimba model with inductive approach show that the average of spatial intelligence = 8.26 and the standard deviation of 3,93. Whereas the students' achievement = 0,52, which categorized as moderate, and the standard deviation of 0,14. Moreover, the creativity of TCIA = 18,82 and the standard deviation of 1,91 (Table 1).

The calculation results of the correlation test simultaneously show that there was a signifi-

cant relation between spatial intelligence and learning results toward creativity with the correlation coefficient (R) = 0,474, categorized as medium and the coefficient of determination (r)= 0,225 or 22,5% at a significance level of 0.019 <0.05. Partially, both spatial intelligence and students' achievement correlated significantly with creativity at the significance level of 0.021 and 0.017 <0.05. The regression equation is $Y = 14,090 - 5,753x_1 + 0,210x_2$

The learning process using the wimba model shows that the deductive and inductive approach is capable of supporting creativity at the moderate level, seen from the results of correlation test that there was a significant relationship between spatial intelligence and students' achievement on creativity in both approaches. The implementation 3D courses had a positive impact on students' success (Sorby, F2009). In the deductive approach, only spatial intelligence had a significant relationship with creativity. This is in contrast with the inductive approach in which both spatial intelligence and students' achievement correlated significantly with creativity. This

suggests that only spatial intelligence supports creativity in the deductive approach, while the students' achievement and spatial intelligence supports creativity in the inductive approach. Therefore, the inductive method is better than the deductive for teaching mathematics (Atta, MA., M. Ayaz, Q. Nawaz (2015) The deductive approach could better develop spatial intelligence. The deductive learning started from concept map, discussion (lecture/theory) and 3D microscopic representation (Figure. 2). The 3D representation activity in a lab was successful after the lecture has been able to encourage students and improve their achievement at the moderate level. On the other side, the inductive learning started with understanding concepts in 3D representation done in a lab. After that, lecturing was performed in a classroom. These activities positively motivated the students to learn independently resulting in the students' creative works. Kurnik (2008), said that teachers should raise students' curiosity and show them the way to new innovations in accordance with the inductive method.

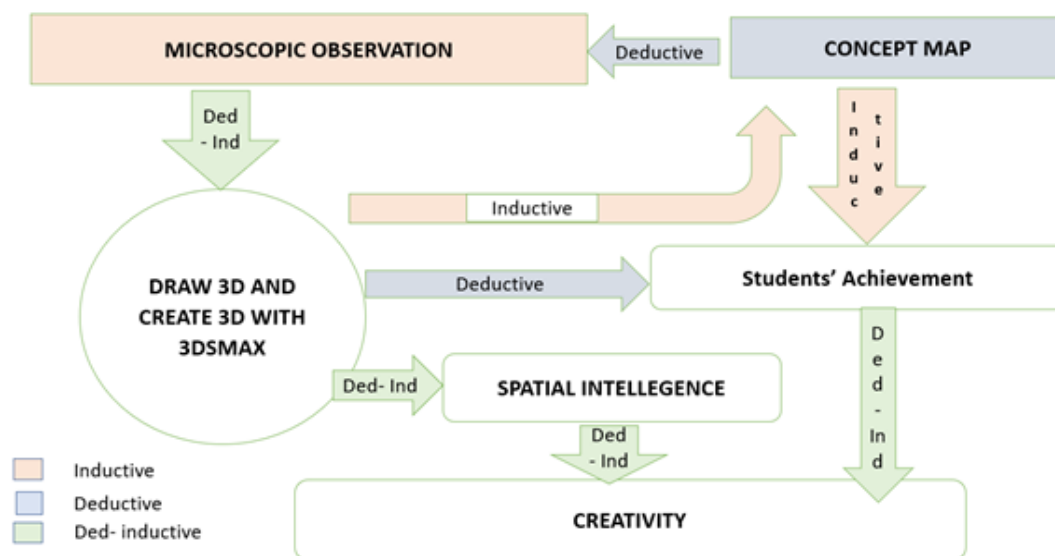


Figure 2. The Research Flowchart

Spatial Intelligence

Spatial intelligence defines as the ability to generate, retain, retrieve, and alter structured visual images well (Thorndike & Lohman, 1990). Spatial skills emphasize different aspects of the process of image creation, storage, retrieval, and transformation. Spatial skills is an important construction of all models of human capability. Everyone needs spatial intelligence for everyday life. This intelligence is very helpful for a per-

son not to get lost or lose direction. For instance, when we arrive in a city that has a relatively similar building, housing, or even when getting into the forest at mountain climbing. The spatial intelligence trains a person to be able to estimate space s/he needs in order not to touch others while walking or driving. Lately, people forget the importance of developing the space intelligence since it is not considered important. In fact, someone with vigorous spatial intelligence usually

has a better mathematical ability and is faster in decision making. Several studies have shown that spatial intelligence indicates gender. Usually, men have better spatial intelligence and women have better verbal skills as boys generally play outside (outdoor) with games that train their spatial intelligence just as playing ball, playing basketball, marbles, and others. The deductive approach in the wimba learning model was able to develop better spatial abilities than the inductive. The process, which began with concept mapmaking followed by a 3D representation through microscopic representation, has been able to stimulate better spatial abilities. The result of the average space intelligence test on the deductive approach was 11.91, while the inductive approach was 8.26 (Table 1). On the contrary, the deductive learning starts from general to special, from abstract to concrete, while spatial intelligence does not obtain through repetition or drilling (Atta, 2015). The students learned using the deductive approach were livelier during the observation since they have understood the concepts and knew the cell shape before microscopic observation. This made it easier for the students to observe, draw cell shapes, and allow them to create concrete 3D shapes on 3DsMax software. This process could improve their spatial intelligence.

Students' Achievement Improvements

The visuospatial-based of Wimba learning led the students to learn the concept of plant anatomy in detailed 3D, while the task of creating a concept map confirms that the students comprehended deeply the plant anatomy concepts (Figure 2). This was proven to have an impact on cognitive learning outcomes. Mei Lu, F., et al., (2008) conducted the research on the use of transparency embryo models that seems to help students expand their view of embryonic development from two to three dimensions. Korakakis et al. (2009) and Hsiung & Lai (2013), stated that 3D learning increase students' achievement and decrease cognitive load. Goldberg & Dintzis (2007), found that there was an increase of 8- 14 points on the identical final exam given over the last 5 years on inductive microscope-based virtual learning in physiology and histology.

The improvement of students' achievement in the deductive and inductive approach was favorable and categorized as 'moderate'. Thus, it indicates that the ability of visuospatial representation could improve the students' achieve-

ment in the 'moderate' category. The improved students' achievement were categorized according to Hake (1998).

An inductive approach is an approach beginning with certain or simple examples and concrete illustrations which leads to abstraction rules, general and complex. The inductive approach is well-suited for biological learning that starts from observations of concrete objects. The curiosity raised during an inductive learning may lead to in-depth learning and meaningful internalization processes (Atta, 2015). The low students' achievement likely occurred in deductive learning, showing that the Wimba learning is better if it is combined with the inductive approach.

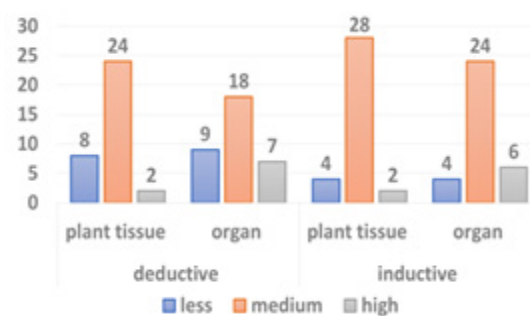


Figure 3: Students' Achievement Categories (Ngain) According to Meltzer (2002)

Creativity

In dealing with the Z and alpha generation or so-called as the digital generation, all teachers must prepare their students to increase creativity. In this digital era, workers compete with robots. Hence, when children are not equipped with creative thinking skills, they are unable to survive and lose the competition with robotic and digital devices. This model is prepared for children of robotics generation that are creative, active and fond of using virtual applications.

Creative people are those who can survive in the competition of life. To overcome this, the Wimba learning model is one solution that can train students to think creatively by doing a 3D representation and will have an impact on improving the creativity of students. Studente et al. (2016), stated that creativity is a specific domain and the steps taken practically to enhance creativity must be aligned with the target domain

The Test of Creativity Imagery Ability (TCIA), is a way of measuring creative visual imagination, reconciling research of creativity and imagination, and presenting a new psycho-

metric instrument (Jankowska & Karwowski, 2015). Creative imagination consists of three interrelated components: clarity, originality, and transformation. TCIA is suitable for this study as the Wimba learning model also involves three components of creating images with a high degree of complexity and detail (clarity), resulting in a unique (originality) and transformative image (controlling change of shape). The Wimba learning model also uses imagination when representing 3D with a high level of complexity and detail. The hectic activities are to represent the results of microscopic observations from 2D images into 3D. This imaginative mental activity is able to stimulate the brain's creativity.

The results show that Wimba learning model with inductive approach was able to develop creativity better than the deductive approach. The inductive learning which began with microscopic observations has made them more creative.

The Correlation of Spatial Intelligence and Students' Achievement on Creativity

The visuospatial-based model of Wimba learning, particularly in the inductive learning, supported students' achievement and creativity. Davis & Rimm (2004), stated that a student's creativity can be stimulated by assigning tasks that involve convergent and divergent thinking. Creativity could also depend more on the domain-specific cognitive skills, such as visuospatial abilities, or verbal skills (Palmiero et al., 2010). Palmiero et al. (2015) stated that the linkage between the spatial ability components of visualization has a role in promoting creativity. Imagining the spatial shape by transforming it into 2D and 3D form before matching to other spatial forms enable one to develop creative ideas. The inductive learning done in this research started with microscopic observation, 2D image representation and then rotating to create 3D image design, and 3D concrete with 3DsMax (Figure 4 and 5). It continued with concept maps, which had a better impact on the students' achievement and creativity. The cognitive process of the inductive approach was an in-depth learning process through meaningful internalization. Such cognitive processes helped students to incorporate ideas so as to make them perceived more solutions or ideas. This is in line with the findings of Fatimah, (2015), Nuswawati & Taufiq (2015), Nuswawati et al, (2017) who revealed that creativity would improve when someone is facing a problem since s/he would think of various solutions that make her/him more creative.



Figure 4. 2D Picture of a) the Transverse Incision and b) the Longitudinal Incision of *Zea mays* stem (400x)

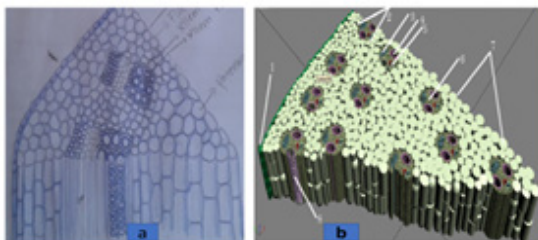


Figure 5. a) 3D Design and b) 3D Design Using 3DsMax

The calculation results of the correlation test simultaneously indicate that there was a relationship between spatial intelligence and students' achievement on creativity in the inductive approach. The correlation show a moderate relationship ($R = 0.474$). However, partially, spatial intelligence and students' achievement had a significant relationship with creativity. Thus, the results of this study convinced that the Wimba learning model in the inductive approach was more effective in improving spatial intelligence, students' achievement, and creativity.

The overall multivariate correlation test computation of the Wimba learning model with deductive approach shows that there was a significant relationship between spatial intelligence and students' achievement on creativity at the moderate relationship category ($R = 0.451$). Therefore, the Wimba learning model on the deductive approach, spatial intelligence, and students' achievement could influence creativity at the moderate level. The results of partial calculation tell that only spatial intelligence having a significant relationship with creativity at the significance level of $0,011 < 0,05$. This suggests that spatial intelligence has a stronger relationship to enhance creativity in the deductive approach.

Spatial transformation places heavy demands on working memory so that spatial tests frequently show high correlation with general ability tests. Thus, the spatial ability could support higher-order thinking in Science and Maths. Palmiero et al. (2010) said that creativity depends more on the domain-specific cognitive skills, such

as visuospatial abilities and verbal ability. In addition, presentation and discussion of visual-spatial results conducted in this research provided linguistic experiences to the students. Thorndike & Lohman (1990) stated that the ability to produce visual-spatial models coordinated with linguistic inputs will have a broad impact on all stages of cognition. Individuals achieving a high score on the ability to create and manipulate such models are likely to succeed in jobs requiring the spatial skills, also, tend to produce such models spontaneously during their thinking process. However, if their verbal fluency is relatively low, they become more introverted.

CONCLUSION

It concludes that the Wimba learning model, i.e. the visuospatial-based microscopic representation learning model on deductive and inductive approach shows that there was a relationship between spatial intelligence and students' achievement on creativity, which categorized as the moderate relationship. It means that spatial intelligence and students' achievement learning outcomes can support creativity. The inductive Wimba learning model was more effective in improving spatial intelligence, students' achievement, and creativity. Nevertheless, the deductive approach in this research could increase spatial intelligence better.

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STRENGTHENING STUDENTS' CHARACTERS AND ECOPRENEURSHIP THROUGH SCIENCE, ENVIRONMENT, TECHNOLOGY, AND SOCIETY COURSE**Martini*¹, L. Rosdiana², H. Subkti³, B. Setiawan⁴**^{1,2,3}Science Education, Universitas Negeri Surabaya, Indonesia⁴Science Education, National Dong Hwa University, Taiwan**DOI: 10.15294/jpii.v7i2.14338**Accepted: February 23rd, 2018. Approved: May 11th, 2018. Published: June 30th, 2018**ABSTRACT**

The purpose of this research was to strengthen characters and ecopreneurship of students who enrolled in science, environment, technology, and society (SETS) course. The focus of the students' characters in this study included responsibility, discipline, creative and innovative, commitment, and cooperative. This course supports the students to develop ecopreneurship to create products from organic and inorganic waste treatments. To achieve the purpose of this research, a teaching and learning package including syllabus, lesson plan, and assessment criteria were developed using the Research and Development (R&D) method. A total of 42 science education undergraduates and two experts were involved in this research. The data were collected through validation sheets, observation sheets, and assessment of students' ecopreneurship products. The validation results showed that the developed teaching and learning package categorized as very good. In this course, six stages of learning were implemented including identifying a problem, making a plan, conducting an observation, collecting information, exhibiting a product, and writing ideas. The observation results showed that the overall developed teaching and learning package was effective to support the students' learning in each of the six stages. Moreover, the improvement in students' scores on the focused characters was observed. At the end of the course, the students' ecopreneurship products were also accomplished. Nine of the products were made of organic waste, while the two of them were recycled from inorganic waste. Thus, it concluded that the course of science, environment, technology, and society could strengthen the students' characters and ecopreneurship.

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Keywords: characters, ecopreneurship

INTRODUCTION

The Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Negeri Surabaya, has KKNi and SNPT curriculum characterized by ecopreneurship. It aims to produce graduates characterized by ecopreneurship. The scope of the success of an ecopreneur-minded learning is through three components, namely: (1) eco-innovation; (2) eco opportunity; and (3) eco commit-

ment (Curriculum Development Team of FMIPA Unesa, 2017). Therefore, the Science Education as one of the study programs in FMIPA also needs to refer to the curriculum of FMIPA.

One of the subjects in the Science Education program, i.e. science, environment, technology, and society of SETS course designs learning that leads students to ecopreneurship. Through the task of identifying scientific issues related to environmental issues, students are expected to apply eco-opportunity. Having the reasoning and creative thinking skills, the students find solutions

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to these problems and develop new environmentally-insightful ideas in entrepreneurship. The process leads the students to do eco-innovation. To achieve the eco-opportunity and eco-innovation, surely, the students must also have eco-commitment which is behavioral characteristics. Through the SETS learning, character education is conducted for strengthening the character of students.

Character education is an attempt to influence one's characters so that s/he could understand, pay attention to, and uphold key ethical values such as respect, honesty, responsibility, fairness, and care (Afrizon, et al., 2012).

Why does character education need to be grown in the SETS course? It is because students of the younger generation who are also citizens should have positive, creative, critical, and trusting attitudes and behaviors in order to hold the nation's leadership baton in the future. Students should act as the agent of change. These attitudes and behaviors are needed to face the increasingly tight competition in the global era (Winarsih, 2015).

The results of observation and interview with the students found that the students have not taken a role in environmental management. In the interdisciplinary lectures discussing environmental issues, students were able to identify the types of garbage found in the campus and surrounding environment ranging from dry leaves, various plastic waste, paper, and so on.

They knew that waste is classified into two; organic and inorganic. The organic waste could be processed into compost, etc., whereas the inorganic waste could be recycled into handicrafts, and so on, but only thirteen percent of the students involved in environmental management for waste utilization. The researchers argued that the students need to be directed to do positive things that they already knew, thus, they could play a role in environmental management. Another supporting thing is the result of the garbage identification done by the students, a lot of materials were obtained and used as learning resources and processed so as to have economic value.

Starting out of this background, the researchers designed a lesson integrated with character education and ecopreneurship in SETS course. The goal was to strengthen the character of students including responsibility, discipline, commitment to work, creative-innovative, and cooperation. A character is a way of thinking and behaves for each individual to live and work together, either within the scope of family, society or nation. (Maryono, 2015). The character configuration

in the context of psychology and sociocultural could be divided into four processes, which are: thinking (creative and innovative), feeling (responsible), working (work ethic), and exercising (discipline and cooperative/ cooperation) (Maryono, 2015).

The character formation is essential and urgently done. We have to build nice characters, ethics, and attitudes to develop this nation (Suastra et al., 2017). Human resources having good characters are required in national development (Suastra et al., 2017). This research's novelty takes place on the character building which was combined with ecopreneurship. Why? Since learning strengthens the character and fosters the ecopreneurship through environmental awareness by finding problems related to waste, finding solutions, conveying ideas, and developing inventions/innovations of organic and inorganic waste processing to produce goods/crafts. This is in line with Adinugraha (2017), who revealed that entrepreneurial skills could be cultivated through the making of Biology learning media made of paper, cardboard, iron/zinc, wood, and electronic devices. Similarly, Widiyatmoko & Pamelasari (2012), developed and produced IPA learning tools by utilizing secondhand materials.

The importance of learning includes: (1) enhancing concept understanding on Science related to organic and inorganic waste, its processing and utilization, so that students are able to create more innovations; (2) cultivating environmental care to the students by minimizing waste through the 6R processes (refine, reduce, reuse, recycle, recovery, retrieve energy), and (3) equipping students with ecopreneurship skills through the utilization of materials that having no economic value. There are twenty indicators of ecopreneurship and one of which is environmental education (Moghimi & Alambeigi, 2012; Pichel, (2008).

Seen from the above three purposes, those are in accordance with the demands of the SNPT-KKNI curriculum that sets S1 students to have attitude competencies, general skills, special skills, and knowledge mastery (Endrotomo, 2015).

To run the KKNI and SNPT curriculum characterized by Ecopreneurship, it is essential to choose appropriate learning approaches/ methods, design learning scenarios, select assessment techniques, develop the instruments, and interpret the assessment results (Curriculum Development Team of FMIPA Unesa, 2017).

Related to the implementation of KKNI and SNPT curriculum characterized by Ecopreneurship, the planning stage began by examining

the character in SETS course. The researchers, in addition to adopting the definition of character from Maryono (2015), also adopted the opinion of Machin (2014), that character is related to the understanding (head), caring (heart) and acting in accordance with the main ethical value (hand). Thus, character education should cover the above three aspects (head, heart, hand) through habituation.

There are four types of character that could be developed during the educational process, which are: (1) cultural-based character education, which is the truth of the God's revelation; (2) cultural-based character education, for instance, in the form of manners, Pancasila, literary appraisal, exemplary historical figures and national leaders; (3) environmentally-based character education; and (4) self-potential-based character education, i.e. personal attitudes as the result of self-awareness process on self-potential. Those are directed to improve the quality of education (Machin, 2014).

In line with the above opinion, the SETS course was designed on character-based and self-based character education. The students can act as agents of changes, through creative, critical attitudes and behaviors developed in learning covering the aspects of the process, person, environment, and product (Winarsih, 2015). In the process, the students are expected to show an interest in discussion, solving problems, assignments, and working together.

Individually, a student must highly commit to assignments, as seen in his/her discipline and tenacity. Students must be able to identify and solve environmental problems and provide solutions to overcome it. The solution is expected to lead them to create innovative, novelty, interesting, and useful works/products.

In this context, character education is highly relevant to be inserted in SETS lectures, as it combines four components of science, environment, technology, and society. The characters are integrated with values using constructivist and constructionist ways. The constructivist explains that students build knowledge through their interaction with the environment. By building an investigation, communication, or activity, a student could build new knowledge and relate it to their prior knowledge.

Khusniati (2012) stated that learning by making use of prior experience can help students construct learning materials. Moreover, learning by doing could increase students' active participation. The constructionist tells that an individual can grasp best when s/he builds a work that

can be shared and judged. Another important element of constructionists is that the work produced must be personally meaningful, in which students can be interested in what they learn or do in the learning process. This corresponds to character education which is a development curriculum aimed at teaching students to make informed and responsible choices for acquiring the required knowledge, skills, and abilities (Tannir & Al-Hroub, 2013). Considering the foregoing, the constructivist description in the SETS lecture is that the students try to identify environmental problems and extract information to solve the problems. In this step, the students would interact with their friends and the people around them (informants) to obtain information, so that they can gain new knowledge.

At the constructionist stage, the students combine new information with their prior knowledge to provide solutions to environmental problems and create technology-based works by utilizing inorganic and organic waste that can be shared with others. For example, how rice husk can be transformed into something more beneficial like compost.

The students' positive attitude toward ecopreneurship will arise if they realize that it is not easy to find a job. In addition, it is not easy to start a business without a determination to be successful. Therefore, the SETS course directs students to produce goods that can be sold to the public. It is appropriate if the integration of character education is also followed by developing the ecopreneurship. Thus, students do not have to think about "where I should go to work", they are no longer a job seeker, rather, they would think of "what kind of work they can do to develop themselves and their environment". In other words, they are job creators (Sulistiyorini, 2013).

There are 4 (four) competencies formulated in this SETS lectures, which are: (1) Making use of Science and Technology to identify the environmental problems or science, environment, and technological issues. Also, to find alternative solutions based on scientific innovation, environment, technology, and community; (2) Mastering science, environmental, and technological concepts and its application in everyday life to review alternative solutions on science, environmental, and technological problems, also, to develop innovation based on science, environment, technology, and community; (3) Making strategic decisions in accordance with the observation and Science theory study to pick and decide solutions on science, environmental, and technological issues. Also, to find alternative solutions based on

scientific innovation, environment, technology, and community; and (4) Responsible for the assignments presented in the form of proposals, reports, and scientific articles. Avoiding detailed references and research result presentation

METHODS

The method used was Research and Development (R&D), having the steps adopted from Ferinch in Subekti & Hidayati (2013), including planning, design, development, implementation, and analysis. All stages passed through evaluation and revision.

At the planning stage, an analysis on Higher Education applying the SNPT-KKNI curriculum was conducted, in which learning achievement should cover 4 (four) aspects, namely: attitude, general skills, special skills, and mastery of knowledge. These achievements are pursued through the formulation of four competencies as described above. In addition to curriculum analysis, student analysis is also conducted.

According to Piaget in Jansen (2011), there are four stages of cognitive development, namely: sensorimotor, preoperational, concrete operations, and formal operations. Each stage is related to a specific age, so, the student is at the formal operation stage. At this stage, a person is no longer needs concrete objects to make rational decisions. S/He should be able to think abstractly. Therefore, in the process of knowledge dimension, students must be in the category of high-level thinking skill, i.e. analyzing, evaluating, and creating.

In the designing stage, an analysis of the study materials on environmental or community issues was done through identification, the discovery of alternative solutions, the development of invention/innovation based on science, environment, technology, and society in the form of project tasks, arranging proposal, reporting, and scientific publications.

The syllabus was prepared at the development stage, taking into account the indicators of competency achievement. In addition to the syllabus, the lesson plan and the assessment were also compiled. All three devices were validated, before being implemented. The implementation was conducted on the 42 Science Education undergraduates, class of 2012.

The data collection techniques used were observation, validation, documentation, and interview. A descriptive analysis was employed to analyze the data.

The instruments' eligibility criteria were defined using the following equation:

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

Information:

\bar{x} = the mean validity

x_i = the validity score of the i to n assessment aspect

n = number of assessment aspects

For instrument validity:

x_i = the validity score of the i- validator to-n

n = number of validators

The instruments have good validity when $\bar{x} \geq 3$, based on the criteria as shown in Table 1.

Table 1. The Validity Criteria

No	Criteria	Score
1	Very high	3,1 – 4,0
2	High	2,1 – 3,0
3	Moderate	1,1 – 2,0
4	Low	0,0 – 1,0

(Best & Kahn, 2006)

The criteria for the learning implementation were determined based on observation scores were done by two observers. The agreement between the observers was calculated by the Kappa coefficient equation.

$$Kappa = \frac{Po - Pe}{1 - Pe}$$

Information:

Kappa = The coefficient of agreement between observers

Po = The value of the observed agreement

Pe = The value of the expected agreement

(Walker, R.A., 2011)

The Kappa coefficient criteria can be seen in Table 2 below. The learning implementation is considered good, if the Kappa coefficient $\geq 0,61$.

Table 2. The Kappa Coefficient Criteria

Score	Criteria
0,81 – 1,00	Very good
0,61 – 0,80	Good
0,41 – 0,60	Moderate
0,21 – 0,40	Low
0,00 – 0,20	Very los

(Walker, R.A., 2011)

The instruments' effectiveness was assessed on the basis of the KKM score of ≥ 61 , or 'good' criterion.

RESULTS AND DISCUSSION

The Feasibility of The Learning Devices

The learning devices that are in accordance with the goals to strengthen the character of students and develop ecopreneurship, thus, the learning was designed in a constructivist way. Therefore, the students could build new knowledge through interaction with the environment. They constructed further knowledge, created shared and judged works.

Another important element of the constructionist is that the students' enthusiasm for what they learn so that they are fully engaged in the learning process. As a result, the produced goods are meaningful for them. This is in line with Khusniati's (2012) opinion, that the material will be easy to understand if the students do activities to grasp it.

In the SETS course, learning was structured by following the stages referring to the achievement of the four competencies above. According to the results of Focus Group Discussion (FGD), the developed learning stages of the SETS included: (1) criticizing and planning; (2) collecting data through field studies; and (3) writing and performance. These steps are illustrated in Figure 1 below.

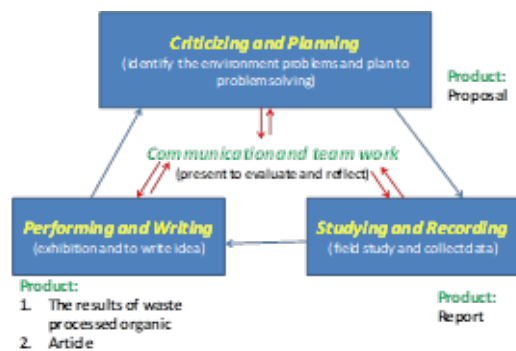


Figure 1. The SETS Learning Stages (Adapted from de Bettencourt K.B., 2000)

The above stages could encourage students to discuss and explore; as a result, it gave the students the opportunity to generate their potential to invent and innovate. This is in line with Zoller (2013), that learning STSE (Science, Technology, Society, Environment) can change: "teaching" to "learning", "knowing" to "thinking" and "teacher-centered, authoritative, frontal instruction" to "student-centered, real-world, project / research-oriented team learning".

To support the character and ecopreneurship-based learning implementation, the learning devices were developed, consisting of the syllabus, lesson plan, and assessment. The validation results by the experts on the learning media are presented in Table 3

Table 3. The Validation Results of the Learning Devices

The Learning Devices	Score		Mean	Criteria
	V1	V2		
Syllabus	3,54	3,46	3,50	Very high
Lesson Plan	3,58	3,58	3,58	Very high
Assessment	3,50	3,40	3,45	Very high

Based on the validator agreement score, it obtained the Kappa coefficient of 0,847 (very good) for the syllabus, 0,667 (good) for the lesson plan, and 0,8000 (good) for the assessment. The sig. Value for the three devices were 0,002; 0,010; and 0,021 respectively. Thus, the sig. $< 0,05$ (α), Which means that there was a strong agreement between the validators.

The Implementation of The Learning Devices

The SETS learning tools had 6 (six) stages, namely: criticizing/identifying the problems (criticizing); planning (planning); conducting field studies (studying); collecting data (creating); presenting the work through the exhibition (performing), and writing ideas (writing).

At the criticizing stage, the students found environmental issues by making observations on the environment around the place of learning (campus) or around their home. The urgent environmental issues were selected as project task topics which were further outlined in the proposal.

The results of this study showed that in the criticizing and planning stage, in which the students were asked to identify problems and find solutions to these problems, they were able to carry out the task. This is in line with Nuswawati & Taufik (2015) opinion, that learning with problem-solving strategies could build students' thinking processes, involvement, communication skills, and information sharing.

One example problem that criticized by the students was the waste rice husk that has not been fully utilized. The students had the solution to process the waste of straw into fertilizer so that it would have economic value. By studying the techniques of making fertilizer and digging infor-

mation to the sources (fertilizer producers), the group could produce fertilizer made of waste rice husk having almost the same quality compared to the others used by the community. The results of the criticizing and planning stages are shown in Table 4 below.

Table 4. The Results of Criticizing and Planning-Stage

Group	Types of waste processing		Score	
	organic	inorganic	criticizing	planning
I	√	–	87,8	79
II	√	–	64,3	70
III	√	–	83,5	82
IV	√	–	85,7	89
V	–	√	64,3	84
VI	√	–	75,9	77
VII	–	√	67,1	65
VIII	√	–	82,2	88
IX	√	–	85,7	86
X	√	–	72,2	76
XI	√	–	79,4	76

The assessment on identification results at the criticizing stage included: (1) conformity of project tasks; (2) the sharpness of the problems; (3) a review of science, environment, technology, and society aspects; (4) solutions offered; and (5) data sources. The assessment percentage for the five aspects, respectively were: 0.15; 0.20; 0.25; 0.25 and 0.15. The scores for each aspect were ranging from 1, 2, 3, 5, 6, 7 (1 = Poor; 2 = Very poor; 3 = Less; 5 = Fair; 6 = Good; 7 = Very good).

From the observation results, some groups were quite careful in critiquing the problems in the environment. The results of the criticizing stage showed that the group 1, 3, 4, 8, and 9 achieved a score of ≥ 81 , and belonged to 'very good' criteria. This was because the members of these groups were students with high achievement index (> 3.5) so that they were able to think critically and

respond well to the tasks given, including the task for the next step, which was the planning.

The assessment at the planning stage (proposal writing), covering aspects of the title, situation analysis, problem formulation, application of science concept, clarity of thinking framework, clarity of problem-solving design, clarity of location and resource, completeness of observation, scheduling, bibliography, language. The span of scores for proposals was from 0 to 100.

At this stage, there was a group obtaining the lowest score, which was 65 (group 7). This was due to their lack of clarity of the situation analysis and the problem-solving design. Group presentation activities gave the students opportunities to evaluate and reflect on each task generated. Thus, there was an increase in score over time within the six stages of learning. This is in line with the opinion of Ahmad, et al. (2016), that cognitive development is the construction of thought processes including remembering, solving problems, and making decisions.

The learning outcomes at the studying stage are shown in Figure 2. The criteria for assessment in the studying stage were similar to the planning stage; there was only one additional criterion that was the assessment of the field study results containing the breadth of information/data obtained from sources/interviewees, and ease of the design. In Abu, et al. (2015) they stated that field studies need to be sustainably done by teachers.

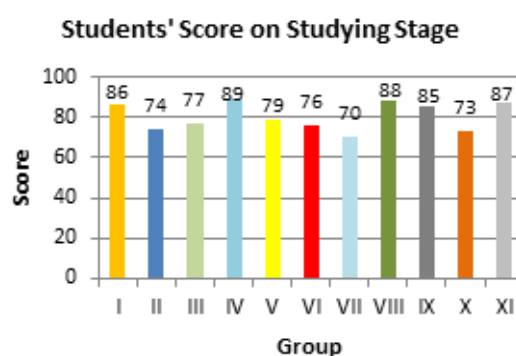


Figure 2. Students' Score Graph on Studying Stage

In addition to preparing reports from field studies, the students also processed organic/inorganic waste into useful products. Here are the student products on the creating stage.

Table 5. Products on the *Creating* Stage

Group	Product
I	Straw compost
II	The dregs of tofu chips
III	Handicrafts, planting media, and bioethanol
IV	Anti-mosquito sapray
V	Mornik paper (organic motif)
VI	Balsam babe
VII	Tissue box, leaf-patterned dress
VIII	Bioflow
IX	Biogas
X	Alternative fuels
XI	Bioethanol

At the performing-writing stage, the students displayed their works by holding an exhibition followed by all groups. The assessment at the performing stage included: product, stand appearance, and the ability to present/elaborate ideas. The products were graded in terms of creativity and innovation of ideas, neatness, suitability of material selection, economic value, and benefits in everyday life. The stand performance was scored by its harmony with the decided theme, neatness, cleanliness, creativity, and stand layout. The ability to present and elaborate ideas were rated by how they describe the products briefly and clearly, also, their ability to answer the jury's questions about the products. The rubric assessment for each aspect was: 1 to 4. Score 1= not in accordance with the theme and not interesting, score 2 = not in accordance with the theme yet interesting, score 3 = suitable with the theme but not interesting, and score 4 = suitable with the theme and interesting.

In the final stage, writing, the students wrote down the results obtained from the beginning to the final stage in the form of written ideas/scientific articles or student creativity proposal.

The observation results of the implementation of learning devices by two observers are presented below.

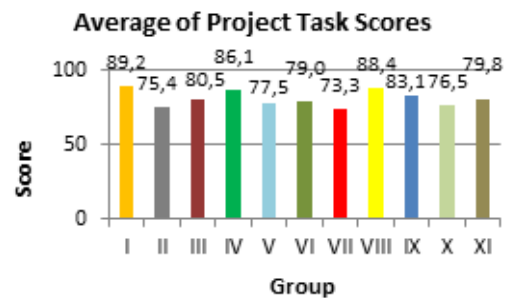
Table 6. The Observation Results

Stage	Mean	Kappa Coefficient	Sig.	Criteria
Criticizing	3,64	0,744	0,000	Good
Planning	3,86	0,588	0,002	Fair
Studying	4,09	0,725	0,001	Good
Creating	4,18	0,569	0,022	Fair
Performing	3,95	0,863	0,000	Very Good
Writing	3,91	0,750	0,000	Good

According to the agreement scores between the observers, the sig value. for all stages was <0.05 (α). Thus, there was a strong agreement between the two observers.

The Effectiveness of The Learning Devices

Seen from the project assessment tasks on all stages, it found that 10 groups had reached the mastery learning ≥ 75 . There was only one group that has not reached the mastery learning, since the scores at the three initial stages were low, respectively 67.1, 65, and 70. This was due to their lack of clarity in problem identification and selection of solutions, resulting in an average score of only 73.3. The overall result of the group is presented below.

**Figure 3.** The Overall Results of the Goup

There were 4 groups achieved 'very good' criteria (≥ 81) and 7 groups achieved 'good' criteria (≥ 61). Those results showed that the learning was effective. Susilogati, et al. (2014) stated that teaching SETS (Science, Environment, Technology, and Society) course could encourage students to do investigations to gain knowledge. The average scores for the six sta-

ges of criticizing, planning, studying, creating, performing, and writing, are shown in Figure 3.

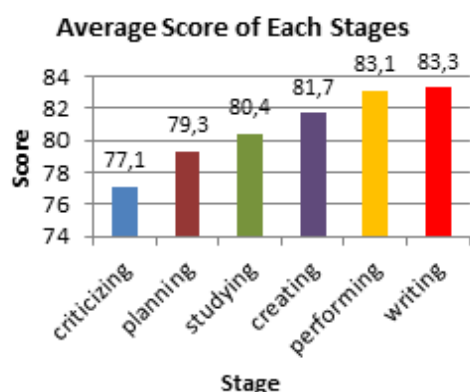


Figure 4. The Average Score of Each Stages

These results indicated that in the first three stages, the students were in the 'good' criteria and 'very good' criteria in the last three stages. Thus, the learning tools were said to be effective.

Character assessment was done throughout the learning process of one semester, including responsibility (completing tasks as required), discipline (compliance with applicable provisions), work ethic (commitment and passion in performing tasks), innovation and creativity, and teamwork. The results of observation/ character assessment on four learning activities of (1) identifying problem; (2) making a proposal; (3) making a report; and (4) conducting exhibitions are shown in Table 6 below.

Table 6. The Character Score on Four Activities

Character	The Activities			
	1	2	3	4
Responsibility	4.00	4.09	4.36	5.00
Discipline	3.91	4.00	4.09	4.92
Work ethics	3.82	4.27	4.36	4.45
Innovation and creativity	3.45	3.45	3.55	4.45
Teamwork	4.18	4.64	4.64	4.72

The four reinforced characters referred to the noble values of character traits (Maryono, 2015) namely thinking (creative and innovative), feeling (responsible), working (work ethic), and exercising (discipline and cooperative/ cooperation).

Considering the above results, in which the project tasks were systematically designed starting from identifying environmental issues and designing the solutions, thus, character st-

rengthening was done gradually. Throughout the lecturing process, the students demonstrated performance and accounted for their work in the forum/class discussion. This is in line with the research result by Rahayu, et al. (2017), that the problem-based learning model is an alternative model to increase the potential of ecopreneurship and character building. Improvement is gained in the creating, exploring, creativity, innovative, and confidence indicator.

At the end of the SETS course project tasks, the students also produced goods from organic/inorganic waste materials that can be distributed/sold to the community. In short, this lecture has cultivated their ecopreneurship sense. Here is one example of the SETS learning outcomes (Figure 4).



Figure 4. The Rice Husk Fertilizer

CONCLUSION

The research results concluded that a teaching and learning package the SETS including the syllabus, lesson plans, and assessment have been validated and declared feasible. Seen from the practicality, the learning devices can be implemented and included in the 'fair' in the planning and creating stage, 'good' in the criticizing, studying, and writing stage, also, 'very good' in the performing stage. For the effectiveness, the learning devices scored 'good' in the criticizing, planning, and studying, and 'very good' in the creating, performing, and writing. There were four groups achieved 'very good', while other 7 groups achieved 'good'.

In accordance with the development and implementation results, given suggestions are as follows:

(1) The learning devices could be implemented in courses having the same characteristics.

(2) The SETS course integrated with 4 aspects of science, environment, technology, and community. Therefore, strengthening on Science and technology aspect is needed to review alternative solutions and develop invention/innovation broadly.

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THE DEVELOPMENT OF GRAVITY COMIC LEARNING MEDIA BASED ON GORONTALO CULTURE

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ABSTRACT

The aim of the study was to develop Gravity comic learning media based on Gorontalo culture for V grade Elementary School students. The type of the research was developmental referring to the design of 4-D model according to Thiagarajan, Semmel, and Semmel (1974) which consisted of 4 stages; define, design, develop and disseminate. The results of this study indicated that the developed gravity comic are valid and could increase students' responses to learning. This cultural-based comic introduces Gorontalo regional cultures. The percentage of the students' active participation was 93.27% for limited trial and the average students' active participation in field trial was 94.94%. The students' learning result gave 86.75% of classical completeness data for the limited test class, while the field test class obtained an average percentage of 87.37%, and categorized as very good. Therefore, the developed Comic of Gravity materials was declared valid, practical and effective. In sum, it was useful for science learning process in grade V of Elementary School.

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Keywords: comic, gravity, Gorontalo culture

INTRODUCTION

Learning media is one of the tools that affect the learning process. To improve students' learning interest, it is necessary to support an interesting learning medium. The approach of using digital technology as a learning medium has a better and more effective impact than others (Adnan et al., 2017).

According to Putra et al. (2013), the learning process will run effectively and efficiently if supporting media are available. Good elementary level learning media should be tailored to the stages of the students' development. In general, elementary school students are characterized by their liveliness and attraction to colors. Therefo-

re, in the process of Science learning, it requires enchanting supporting media that encourage students to do an independent activity. One of them is the comic learning media.

Comic as a learning medium is a tool that serves to convey instructional messages which can function well as a visual communication learning medium, in which this learning context refers to a communication process between students and learning resources (comics). Referring to Rasiman & Pramasdyahsari (2014) stated that e-comic is a transformation of technologies media comic originated in a printout form into a digital electronic format. Thus, it concludes that a certain storyline in the digital electronic format that has a role as a learning media for students.

One of the advantages of comics is to motivate students during the learning process. Consisting of images, it could improve the quality of

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learning. A comic is a permanent reading prompt that directs students to read curiously especially those who dislike reading. Besides, a comic is a part of popular culture (Wurianto, 2009). Children, including the elementary age, generally like illustrative pictures as well as comics as they found it entertaining. Children would more easily remember the characters and stories of the comics they read. Empirically, the students tend to like colorful picture books visualized in both realistic and cartoon forms (Daryanto, 2010). Comics can present various natural events illustrated concretely for the students.

The V grade children of Elementary School are in the stage of concrete operational thinking. At this part, they can perform concrete operations and reason logically as long as the reasoning is applicable to specific or concrete examples (Santrock, 2012). Therefore, the use of comic learning media is very appropriate for students in elementary school level to be able to improve learning outcomes and responses in following science learning process.

Previous research by Ambayyani & Airlanda (2017) on the development of comic as learning media to increase cognitive learning achievement on physical environment change, revealed that comic could increase elementary students' cognitive learning achievement. Another study by Azizi & Prasetyo (2017) on the contribution of comic learning media for natural science subject with character education on natural resource topic for elementary students found that it could increase students' learning achievement.

Regardless of the findings that comic could improve students' learning outcome, the usage of science-learning comics within the learning process itself is limited and not yet optimized. Therefore, it requires the development of science comic based on Gorontalo culture on gravitation topic as an alternative solution to the limited availability of science comic in increasing the students' responses and learning outcomes, which at the same time optimizing the utilization of comic in science learning on gravitation topic.

METHODS

This study is a developmental research using the 4-D Models developed by Thiagarajan and Semmel (Trianto, 2009). The research steps including: (1) define; (2) design; (3) develop; and (4) disseminate. The developed product

was Gravity comic based on Gorontalo culture to increase students' responses, activities and their learning achievement as well as strengthening the local culture for grade V students. This research has been done in January 2018, in which the stage trials were conducted to 15 students, while the field trials were done in three elementary schools situated in Gorontalo, they are SDN 30 Kota Selatan, SDN 80 Kota Tenganand SDN 71 Kota Utara.

The instruments applied in this research were: (1) Expert Validity Sheet to score the Gravity comic, in which the validation was done by four experts including two Physics education experts and two learning media experts; (2) Interview guideline to obtain the response data in the form of learners' interest and motivation about the Gravity comic; (3) Observation sheet on the use of Gravity comic in learning; (4) Observation sheet on the learners' activities; and (5) Test of the learning outcomes.

The data analysis in this research is explained as follows:

Validation analysis was performed by calculating the average score of the four validators then converting it to the criteria as shown in Table 1.

Table 1. The Validity Criteria

Average	Validity criteria
4,00 – 3,75	Very Valid
3,75 – 3,00	Valid
3,00 – 2,25	Fair
2,25 - 1,50	Less Valid

(Sukardi, 2013)

Based on the above table 1, the comic media in the learning was valid if it meet the 'valid' or 'very valid' based on the experts' judgment.

The Interviews resulted in the response data. The data of the interviews with teachers and students were analyzed, and a conclusion was drawn up from the result of the interview for each indicator. Assessment of the learning implementation was done by matching the average result of the total score given with the following criteria:

Table 2. The Learning Implementation Criteria

Range	Interpretation
86% - 100%	Very Good
76% - 85%	Good
66% - 75 %	Fair
56% - 65%	Low
0% - 55%	Very Low

(Sukardi, 2013)

The assessment of learners was performed by matching the average results of the total score to the criteria in Table 2. Similarly, the learners' learning results were analyzed referring to the 80% for individual mastery and 85% for classical completeness, while the achievement results were then converted to criteria as shown in Table 2.

RESULTS AND DISCUSSION

The development of comic as learning media for natural science subject in gravity topic was preceded by designing the comic. In general, it contains the gravity materials including the notion of gravity, the benefits of gravity, and object motion due to the gravity. The materials are delivered in a simple way and supported by interesting drawings and cultural contents such as Gorontalo historical attractions, Otanaha Fortress, traditional transportation of Bentor, and Gorontalo's traditional house of Dulohupa. In addition, the characters are named after native Gorontalo names for girls and boys.



Figure 1. The Gravity Comic

This research relates to comic and culture. A similar study has been done by Honarvar and Rahimi (2011) in which they tried to investigate cultural problems from children's comic translation.

The experts' validation included Gravity comics validation and other learning devices used to implement comics in the learning process. The Gravity comics validation covered several assessment parameters seen from the construction, content, language, readability, and layout. The obtained validation results were in the form of qualitative suggestion and assessment sheet. The qualitative suggestion became the reference to revise the science comic learning media and other learning tools. After the revision has done, the experts filled in the assessment sheet as presented below.

Table 3. The Validation Results of The Learning Devices

No	Instruments	Category	Feasibility Yes / No
1	Comic	Valid	Yes
2	Syllabus	Very Valid	Yes
3	Lesson plan	Very Valid	Yes
4	Students Activity Sheet	Very Valid	Yes
5	Learning Materials	Valid	Yes
6	Learning Outcome Test	Valid	Yes

Table 3 indicates that the science learning media of gravity comic belonged to the 'valid' category. Thus, it is feasible to be applied in learning processes since it has met the criteria validated by the experts. Those criteria are: the correctness of concepts based on the gravity scientific aspect; the clarity of topic; the correct sequence of the materials; the compatibility of sample materials with the surrounding environment; the compatibility of learning materials with the learning objectives; the compatibility of dialogue or story with the diction in material explanation; showing variety of students' cognitive level; the compatibility of vocabulary with the students' language use; the use of communicative language; the compatibility of theme with the level of students' thinking.

The developed learning tool consists of a syllabus, lesson plans, students' activity sheets, learning materials, and learning outcome test which all included in the very valid and valid category. The syllabus, lesson plans, and students' activity sheets were in the valid category, whereas the learning materials and learning outcome test belonged to the very valid category. This means that the developed comic learning media for gravity topic and its learning tools is favorable for science learning process.

The interview results with the teachers and students indicate that science learning medium of Gravity Comis was applicable in science learning process. The interview with students revealed that the Gravity Comic could increase students' interest and motivation. This is supported by the research conducted by Arini et al. (2017) stating that the use of comic as learning assistance could enhance students' interest regularly.

Moreover, Norsalisa (2013) stated that students' are motivated to learn using comic in their learning process. This result is also echoed by Zain et al. (2013) who said that comic could increase students' learning motivation. In fact, students enjoy reading comics and it has motivational values (Wright, 1979). Since students already have the motivation to use cartoon materials, it should not be ignored by educators as a potential aid in the classroom. The percentage of the Gravity Comic implementation is as shown in Table 4.

Table 4. The Average Percentage of the Learning Implementation

Class	Average Percentage (%)	Criteria
Limited trial class	86.75%	Very good
Field trial class	87.7 %	Very good

Table 4 shows that the implementation of gravity comic was in 'very good' category, in which each learning syntax generally had a pleasing flow. The average score of the limited trial was 86.75%, while the average score of the field trial was 87.37%. These results were due to the practicality of comic, hence, the teacher found no difficulty in implementing each learning syntax. Furthermore, the knowledge was well-delivered considering comic's comprehensive aspect. A research conducted by Negrete (2013) show that

comic is a narration favorable for conveying certain information. Therefore, through interesting delivery, difficult materials could be easily understood by students, and the learning process would be smoothly implemented. Aslamiyah et al. (2017) state that comic can be easily used in the learning process as students love to read comic and this helps them in understanding the learning materials. This is in line with Fedotova et al. (2015) who explained that a comic is a language for the readers to think, muse, and analyze so that it is recommended as a medium to deliver information in the learning process.

The students' activities in the learning process consisted of 7 aspects; listening, reading, writing, asking, answering, solving questions, and making a conclusion. The results of the observed activities are in the following Table 5.

Table 5. The average percentage of the student's activities

Class	Percentage of the Student's Activities (%)	Criteria
Limited trial class	93.27 %	Very good
Field trial class	94.94 %	Very good

Table 5 tells that the students' activity in the learning process using comic was in the 'very good' criteria, in which during the limited trial, the percentage of students' activity was 93.27% and slightly increased to 94.94% in the field trial. This was due to the students' happiness in studying the materials. Hence, it impacted on the increase of the students' activity during the science learning.

This indicates that the utilization of comic could increase the students' participation as revealed by Adinata et al. (2015) who stated that comic is effective in increasing students' activities and learning outcomes. This is also supported by Wahyuningsih (2012) who found that the utilization of comic learning media could increase students' participation in learning.

The students' learning outcomes depend on learning design and student participation (Wardani et al., 2017). Through such learning design using comic and the activity criteria as shown in Table 5, therefore, the learning outcomes obtained are as stated in Table 6. According to the results of the cognitive learning test, it was obtained the data as seen in Table 6.

Table 6. The Average Percentage of the Students' Learning Outcomes

Class	Mastery of Classical Learning Outcomes (%)	Criteria
Limited trial class	93,27 %	Very good
Field trial class	94,94 %	Very good

Table 6 indicates that the percentage of the students' learning outcomes was in 'very good' criteria, in which the percentage of students' learning achievement during the limited trial was 93.27%. This percentage arose to be 94.94% on the field trial. It means that the application of comic in the learning process granted positive contribution to the enhancement of the students' learning results. This is in line with the study conducted by Buchori & Setyawati (2015) who revealed that employing comic learning media could increase students' learning achievement.

The research results by Yulianti et al. (2016) show that learning science by inquiry-based science comic could improve the cognitive achievement of primary school students. A similar result is also shown by Fatimah & Widiyatmoko (2014) who found that the utilization of science comic could increase students' learning achievement. Referring to those studies, gravity comic is feasible in science learning inasmuch as it could increase students' interest, motivation, participation, and learning outcomes.

CONCLUSION

Based on the findings and discussion above, we conclude that: (1) comic media for science subject on gravity topic developed in this study are proven to be very valid by the experts; hence, it is suitable to be utilized in learning process; (2) the students provided positive responses to the utilization of gravity comic, and the implementation of learning using the comic was regarded as very good in which each learning syntax was carried out well or very well, seen from the average score of 87.37% on the limited trial and 87.37% on the field trial; and (3) the students' active participation during the learning process using this comic was in very good category, in which the average students' participation score was 93.27% on the limited trial, and 94.94% on the field trial.

In addition, the students' learning achievement was in very good criteria, seen from the average score of 93.27% during the limited trial and 94.94% during the field trial.

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