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IMPROVING STUDENTS' GENERIC SKILL IN SCIENCE THROUGH CHEMISTRY LEARNING USING ICT-BASED MEDIA ON REACTION RATE AND OSMOTIC PRESSURE MATERIAL

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ABSTRACT

The research aims to obtain information of improvement students' generic skills in science through chemistry learning using ICT-based media on reaction rate and osmotic pressure material. This research was designed with quasi-experimental research method, with the design of non-equivalent control group pretest-posttest design. The research subjects were students of class XI and XII one of Madrasah Aliyah Negeri (State Islamic Senior High School) in Bandung. Learning process in experiment group were conducted using ICT-based media, whereas in control group conducted by applying laboratory activities. Data were collected through multiple-choice test. The result shows that there was no significant difference of n- gain of students' generic skill in science between experiment and control group. Therefore it can be concluded that the learning process using ICT-based media can improve students' generic skills in science as well as laboratory-based activities.

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Keywords: Generic skills in science, ICT-based media, laboratory activities, osmotic pressure, reaction rate..

INTRODUCTION

Knowledge grows fast so teacher needs to prepare or train their thinking skills to learn and understand the concept and does not only directly provide the concept. no longer enough just equipped with the knowledge or concepts. The appropriate skill for science covering chemistry skill inside is generic skill because it can be used to study material or other sciences independently. The generic term is used in terms of its potential and applied to various disciplines and contexts. Similarly Brotosiswoyo (2001) stated that the generic skill in science is the basic skill that is usefully used to learn other disciplines. According Liliasari (2009) generic skill in science as a new paradigm can make students learn science more easily.

More specifically Brotosiswoyo (2001) suggested that generic skill in science consists of direct and indirect observation, awareness of the scalar quantity, symbolic language, framework principles, consistent logic, inference logic, the law of cause and effect, mathematical modeling, and building concepts. The generic skill tends to be more specific on the necessary intellectual skill and is operated in acquiring and developing science related to its character. From the previous description it can be stated that the generic skill in science is skill that is related to the character of science, including chemistry.

Generic skill in science can be said as thinking skills therefore it can be learned and prepared to students through science learning. Chemistry, as well as other fields in science, is the study of natural phenomena. It discusses particularly on substance structure and composition, change of matter and energy that accompanies those changes. Chemistry is learned through the three levels of representation of macroscopic, sub-microscopic, and symbolic levels (Treagust,

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2003; Sirhan, 2007; Talanquer, 2011).

Macroscopic level deals with descriptive knowledge of chemical substances and processes obtained directly (through the senses) or indirectly (using tools), and the experience of empirical knowledge that we understand and collect about chemistry system. This is consistent with Gilbert & Treagust (2009) that stated this type contains representation empirical properties of matter. It is also consistent with Johnstone and Gabel in Gilbert (2008) that stated the macroscopic level represents some aspects of natural phenomena that can be investigated. This level includes what is observed from what is learned.

Submicroscopic level is descriptive, explanatory and predictive of what has been developed of chemist to understand natural phenomena. Gilbert & Treagust (2009) stated that this level is associated with a model that can be explained the cause of phenomenon type. Chittleborough (2004) stated that the sub-microscopic level is as real as the macroscopic level, only the scale is different, and the fact that the sub-microscopic level can not be seen easily make it difficult to accept that it is real.

Symbolic level consists of static and dynamic visual signal (from symbol to icon) that was developed to facilitate qualitative and quantitative way of thinking and way to communicate both. Visualization relates to chemical formula and symbol, depictions of particulate, mathematical equation, graphic, animation, simulation, physical model, and so on, that visually represent a core component of theoretical model. Gilbert and Treagust (2009) stated that the level of symbolic involves the use of symbol to represent atoms, subscript that represents the number of atoms in ions or molecules, or letters to represent the physical state as solid (s), liquid (l), gas (g) and a solution (aq). Symbolic level consists of qualitative abstraction used to represent each item in a sub-microscopic level (Gilbert, 2008). As it grows, this type can be used to describe the type of model (such as: describing physical or chemical changes that occur during the reaction), it can also be used to describe the type of phenomena (such as: the number of reactants and products in the stoichiometry calculations). Symbolic representations are used extensively in the chemistry and used as a learning tool to help explain a macroscopic level and sub-microscopic level in chemistry. The symbolic representation of chemical phenomena includes chemical model as a model of ball-and-stick, space-filling models, structural formulas, chemical equations and computer models, or verbal descriptions, diagrams, analogies, metaphors, images, ideas, or any simulations that can be used to develop students' mental models (Gilbert & Boulter in Chittleborough, 2004). Talanquer (2011) stated that the type of experience consists of empirical part, whereas the type of models and visualization consists of representation section.

Chemistry representation holds an important role, but on the other hand a lot of research show that students have difficulty in understanding submicroscopic representation (Tasker & Dalton, 2006). One of the ways to help them improving understanding of submicroscopic representation is by describing and visualizing processes occured at the molecular level (Sanger, 2000). Wu et al. (2001) research also showed similar results that students are helped by the use of computer-aided visualization tools.

Another difficulty experienced by students is to interpret representations, provide verbal explanation of chemical reactions, and make the translation between the different types of representation showing the weakness of the relationship/link between chemical phenomena, representations, and relevant concepts. Inspired by social constructivist learning, Kozma et al. (2000) suggested that the chemistry curriculum can guide students to use the plural representations visually and verbally to connect it with the phenomena. Compound representation should play an important role in the curriculum and chemistry learning. One of the ways that can be used to help students overcome this is studying the chemistry and its characteristics by using information and communication technology (ICT)-based media.

Computer technology, which is a product of information technology, is able to present the information in various forms such as text, graphic, image, animation, sound and video. The combination of various forms of information is known as multimedia. Ruthven (in Chiu & Wu, 2009) said that multimedia is a powerful communication tool in presenting science, especially natural science. Through video, students are given the opportunity to observe chemistry phenomena (macroscopic level). While, submicroscopic level, containing the explanation of macroscopic phenomena, can be presented through visualization in the form of animation and images.

Gilbert (in Chiu & Wu, 2009) stated that visualization through multimedia can combine students' mental imaginary that is formed when the acquisition of material can be observed and expectedly stayed in their long term memory. Multimedia can also visualize the interaction and dynamic movement that occur in the chemical process by displaying symbol and equation in three dimensions that can not be displayed by other media. The use of multimedia can provide valuable information for teachers about how students conclude, connect and integrate representation of macroscopic, submicroscopic and symbolic (Ardac & Akaygun, 2004).

In line with the previous description of the problem formulation, this research applied learning using ICT-based media to improve the generic skill in science of high school students in studying chemistry. Chemistry materials used as media to develop generic skill in science were osmotic pressure and the reaction rate that was limited to the factors affecting it.

METHOD

This research designed was quasi-experimental research method, with the design of non-equivalent group pretest-posttest design. This design was selected because the sample can not be chosen randomly as experiment and control groups. So two classes that is already available of XI (reaction rate) and two classes XII (osmotic pressure) were directly used as experiment and control groups. This is in line with McMillan & Schumacher (2001) that stated that this design is very useful in education, since it often impossible to randomly assign subjects. The researcher uses intact, already established groups of subjects, gives a pretest, administers the treatment condition to one group and Gives the posttest.

The study was conducted in one of Madrasah Aliyah Negeri (State Islamic High School) in Bandung. Experiment class was treated with learning using ICT -based media, while control group applied laboratory-based activities. Prior to the implementation of the learning process, control and experiment group took the pretest to determine their initial generic skill in science before joining the lesson. After the learning process was conducted, at the end of the lesson students were given posttest to measure the improvement of their generic skill in science.

Measurement of generic skill in science was done by using instrument in the form of multiple-choice question and reason test. There were 15 multiple choice questions on the concept of osmotic pressure and 12 for sub-concepts of the factors that affect the reaction rate.

RESULT AND DISCUSSION

The improvement of students' generic skill in science can be seen from and the results of pretest and posttest data and normalized gain (n-Gain) of each research subject. The complete data of students' in experiment and control groups can be seen in Table 1 to Table 5. Achievement percentage of pretest, posttest and n-gain score average of students' generic skill in experiment and control groups can be seen in Figure 1a and 1b.

E = Experiment

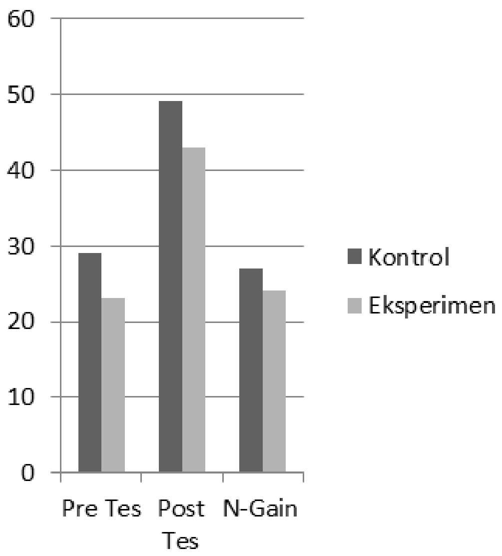

Figure 1.a. Achievement Percentage of Pretest, Posttest and N-gain Score Average of in Reaction Rate Material

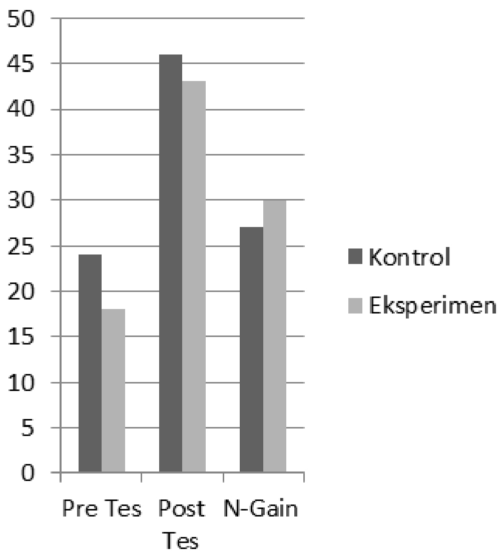

Figure 1.b. Achievement Percentage of Pretest, Posttest and N-gain Score Average of in Osmotic Pressure Material

Table 1. Percentage of Pretest, Posttest and N-gain Score Average of Students' Generic Skill in Experiment and Control Groups in Reaction Rate and Osmotic Pressure Materials.

No	Topic	Pretest (%)		Posttest (%)		*n-Gain* (%)	
		C	E	C	E	C	E
1	Reaction Rate	29	23	49	43	27	24
2	Osmotic Pressure	24	18	46	43	27	30

Notes:
C = Control
E = Experiment

Table 2. Students' Score Percentage of Pretest, Posttest and N-gain of Each Generic Skill in Science (GSS) Indicator of Experiment and Control Groups in Factors that Influence The Reaction Rate Material.

GSS	Control Group			Experiment Group		
	% Pretest	% Posttest	% n-Gain	% Pretes	%Posttest	% n-Gain
GSS 1	35	45	8	17	32	10
GSS 5	20	54	43	19	64	51
GSS 6	27	27	-10	19	18	-7
GSS 8	37	57	21	32	44	15

Notes:
GSS 1: Indirect observation
GSS 5: Logical inference
GSS 6: The law of cause and effect
GSS 8: Building the concept

Generic skill in science (GSS) indicators examined in this research was adjusted to the character of material of factors that influence the reaction rate and osmotic pressure. GSS indicators developed on the concept of factors that influence the reaction rate are indirect observation, logical inference, the law of cause and effect, and building the concept; whereas the concept of osmotic consisting of indirect observation, symbolic language, the law of cause and effect, mathematical modeling, and building concepts. Achievement percentage of pretest, posttest and n-gain score average of each indicator of concept in experiment and control groups is presented in Table 2 and Table 3.

Table 2 shows that the generic skill in science of each indicator in experiment and control group generally has increased except at GSS 6 indicator (the law of cause and effect). On the concept of the factors that influence the reaction rate, the indicator of logical inference in the two groups has the highest value of n- gain (54% and 51%) compared to other indicators.

Table 3 shows that the generic skill in science of each indicator in experiment and control group on the osmotic pressure concept in generally has increased. The improvement of generic skill in the experiment group was in line with the results of Lilasari et al. (2008) and Liliasari (2009) that showed the generic skill in science can be improved by using multimedia-based learning. In the experiment group, GSS 6 of the law of cause and effect indicator had the highest value of n-gain (50%), whereas in the control group mathematical modeling indicator had the highest value of n-gain (63%).

T test using Independent Samples Test and non-parametric test using Wilcoxon test of n-gain of generic skill in science showed that multimedia-based learning on the factors that influence the reaction rate and osmotic pressure materials did not differ significantly in improving students' generic skill in science compared to the use of laboratory activities-based learning model.

T test resulted significance level value of 0,731 on the factors that influence the reaction rate concept and 0,763 on osmotic pressure concept. That value is greater than 0,05. From the analysis it can be concluded that the improvement of students' generic skill in science in both groups did not differ significantly. The statistics test results of each indicator are presented in Table 4 and 5.

Results of statistical analysis of each GSS indicator showed that there was no significant difference on the reaction rate topic, while for the

Table 3. Students' Score Percentage of Pretest, Posttest and N-gain of Each Generic Skill in Science (GSS) Indicator of Experiment and Control Groups in Osmotic Pressure Material.

GSS	Experiment Group			Control Group		
	% Pretest	% Posttest	% n-Gain	% Pretes	%Posttest	% n-Gain
GSS 1	8	55	49	25	58	43
GSS 3	18	15	-7	19	33	14
GSS 6	20	63	50	0	27	27
GSS 7	13	40	37	18	81	63
GSS 8	21	55	43	25	49	30

Notes:
GSS 1: Indirect observation
GSS 3: Symbolic language
GSS 6: The law of cause and effect
GSS 7: Mathematical modeling
GSS 8: Building the concept

Table 4. Statistics Test Result of Each Generic Skill in Science (GSS) Indicator of Experiment and Control Groups in Factors that Influence The Reaction Rate Concept

No	Generic Skill in Science	Normality Test (α=0,05)				t-test/ non parametric test	
		Significance Level		Caption		Sig. Level	Notes
		Con.Gr.	Exp.Gr	Con.Gr.	Exp.Gr		
1	GSS 1	0,001	0,005	Not normal	Not normal	0,852	Not significant
2	GSS 5	0,553	0,126	Normal	Normal	0,364	Not significant
3	GSS 6	0,000	0,000	Not normal	Not normal	0.863	Not significant
4	GSS 8	0,174	0,021	Normal	Not normal	0,608	Not significant

Notes:
GSS 1: Indirect observation
GSS 5: Logical inference
GSS 6: The law of cause and effect
GSS 8: Building the concept

Table 5 Statistics Test Result of Each Generic Skill in Science (GSS) Indicator of Experiment and Control Groups in Osmotic Pressure Concept

No	Generic Skill in Science	Normality Test (α=0,05)				t-test/ non parametric test	
		Significance Level		Caption		Sig. Level	Notes
		Con.Gr.	Exp.Gr	Con.Gr.	Exp.Gr		
1	GSS 1	0,170	0,148	Normal	Normal	0,440	Not significant
4	GSS 3	0,142	0,005	Normal	Not normal	0,042	Significant
5	GSS 6	0,000	0,002	Not nor-mal	Not normal	0,122	Not significant
2	GSS 7	0,000	0,000	Not nor-mal	Not normal	0,048	Significant
3	GSS 8	0,902	0,399	Normal	Normal	0,121	Not significant

Notes:
GSS 1: Indirect observation
GSS 3: Symbolic language
GSS 6: The law of cause and effect
GSS 7: Mathematical modeling
GSS 8: Building the concept

osmotic pressure topic the significant difference was only in GSS 3 indicator (symbolic language) and 7 (mathematical modeling). This showed that ICT-based media in this study gave the same effective result as learning the method of direct experiment.

The almost similar result is derived from research conducted by Liliasari & Wiji (2012), but the subject was college student and it compared ICT-based media and inquiry learning. The result also showed that there was no significant difference between both groups.

Although Russell (1997) and Chow (1997) said that the model of ICT-based learning has the advantage of displaying image, video, photography, graphic, animation, text, and data, to make it possible displaying the chemistry concepts in three-level representation, but the results of this study indicate that such learning is as good as laboratory-based learning activities. Thus ICT-based media can be used as a practical substitute for schools that do not have laboratory facilities.

Since this research of laboratory based learning and ICT-based learning was condocted separately, it might need to be investigated further by integrating those methods. Kozma et al. (2000) research showed that computer-assisted representation can help students in describing their research in terms of the process that they expect to happen and chemical properties of substances resulting from their experiments. Based on these findings the same study with appropriate modifications for high school students can be done further to find out the result.

CONCLUSION

Based on the result of implementation chemistry learning using ICT-based media on the topic of osmotic pressure and the factors that influence the reaction rate, it can be concluded that learning with ICT-based media was sucessful to provide the same effect as good as laboratory-based learning on generic skill in science improvement. The use of ICT-based media is better used to replace laboratory for schools that do not have the facility to improve GSS indicators of indirect observation, the law of cause and effect and building concepts.

For schools that have chemistry laboratory and computer facilities are suggested to involve students in using multiple representations (ICT-based) in conducting laboratory activities particular inquiry (either in asking questions, making predictions or stating the purpose of the investigation that they did. Its effectiveness can be tested further through further research to determine whether the laboratory-based learning integrated with the use of multi representation by computer-assisted can provide better learning outcomes or not.

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