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The Effectiveness of Module Based on Discovery Learning to Increase Generic Science Skills

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Abstract

Generic skills are the skills which needed to face the future. In this study, the generic skills that discussed are the generic skills on the science field, called generic science skills. The purpose of this study is to determine the effectiveness of module based on discovery learning to increase generic science skills. This study was conducted at one of the State Madrasah Aliyah in Surakarta academic year 2016/2017. The pre-test and post-test research pattern with treatment and control class groups were used throughout the study. While the treatment group taught by using module based on discovery learning, the control group was taught by a module that commonly used in the school. As the study concluded, using module based on discovery learning in the learning process is effective to increase generic science skills.

Keywords: *module, discovery learning, generic skill*

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Introduction

The learning of science focuses on learning and concepts through the learning process. Based on the data of Program for International Student Assessment showed that the science ability of Indonesia students are ranked 65th out of 66 countries (PISA, 2012). Besides the results of Trends in International Mathematics and Science Study states that the science and mathematics' ability of Indonesia students are ranked 40th out of 42 countries (TIMSS, 2011). The low quality of student's science competence in Indonesia showed that the science learning in Indonesia was not run well. The success in increasing students' understanding of science can be measured from the students' basic ability while they are in the learning process. This basic ability is known as generic science skills. The generic science skills are the result of a combination of intellectual abilities or complex interactions between science knowledge and skills. The ten indicators of generic science skills include direct and indirect observations, scale awareness, symbolic language, logical frame, logical consistency, causality, mathematic modelling, concept constructing, and abstraction (Brotosiswoyo, 2000).

As revealed by the National Research Council or NRC (2008) that the skill need of future is a variety of generic science skills. Eaton & Whittle (2012) states generic skill in the learning process can prepare students to face a lot of situations in the future. Since the current round of curriculum reforms around the world, development of generic attributes has become an important indicator of higher education success. Generic attributes refer to some favorable personal qualities in additional to academic scholarship which graduates ought to possess in order to become capable citizens (Chan, 2010). The results of the analysis of the needs in one of State Madrasah Aliyah in Surakarta, Indonesia indicate low school achievement of competence in biology material with an average score, it was only 78.84%. Based on data from the national exam's result shows that the respiratory system matter gets the low score and having the decline of percentage for three consecutive years from 2013 to 2015, which amounted to 56.84% in 2013; 33.07 % in 2014; and in 2015 only amounted to 27.45%.

The result of generic science skills analysis in module and book that commonly used in the school showed the score is still low. Aspect direct observation in book one gets score 12.5% and 0,00% in book two; aspect indirect observation in book one gets score 50.0%; aspect scale awareness in both of book one and book two get score 37.5%; aspect symbolic language in book one gets score 29.2% and 25.0% in book two; aspect logical frame in book one gets score 25.0% and 0,00% in book two; aspect logical consistency in book one gets 59.4% and book two gets 25.0%; aspect casualty in book one gets score 75% and book two gets score 0.00%; aspect mathematic modelling in book one gets score 41.7% and 0,00% in book two; aspect concept constructing in book one gets score 75.0% and 25.0% in book two; and aspect abstraction in book one gets 45.5% and 16.9% in book two.

The module is one type of teaching materials that are presented systematically, so that the user can learn with or without a facilitator or teacher. The learning by using module allows students who have a high ability to learn would be faster in completing a basic competence than other students (Ministry of Education, 2004). Septiani, et al. (2014) states that the use of module makes students can learn individually which means that they can adjust the speed of learning according to their ability. In addition, with modules, students can measure the level of their mastery of the material provided. Curriculum 2013 revealed by Ministry of Education and Culture (2014) is demanding the creation of learning process that emphasizes personal experience through the process of observing, asking, reasoning, and trying. Students are expected to have competence attitudes, skills and knowledge that much better through a scientific approach. The learning process like asked by Curriculum 2013 can be applied through a model of discovery learning where learning model uses a scientific approach in the stage of learning syntax. Anders (2012) states that the discovery learning is a learning model in which students can explore, find out, and find themselves in the learning process, so that students take an active role to create, integrate, and generalize knowledge. Jew (2012) adds learning through discovery learning can improve the mastery of materials, retention, and transfer of knowledge and learning are more significant.

Generic science skills can be taught through discovery learning models such asked by Curriculum 2013 with learning through scientific approaches. The essence of Curriculum 2013 that was revealed by Kemendikbud (2014) that students are required to be productive, creative, and innovative through the strengthening of attitudes, skills and knowledge which are integrated. The efforts to increase the active participation of students in the learning process as appropriate to Curriculum 2013 inspired the

researchers to develop a module based on discovery learning at respiratory system subject. The module that developed are expected to support the learning process, guiding students to do the activities independently through structured activities in the module and to increase the generic science skills in students according to the demands of the 21st century.

Method

Participants

The study research involved two (11th grade) classes that consisted of 24 students in each class. The classes were selected by using simple random sampling method with doing prerequisite before that is normality and homogeneity tests. The research design is pre and post-tests non-equivalent control group design. The treatment and control class groups were given generic science skills test before and after learning by using module in respiratory system matter. The treatment class group was taught by module based on discovery learning developed by researcher while the control class group was taught by module commonly used in the school.

Procedure

The study research was conducted ten steps of Borg and Gall development model that modified into nine steps due to the boundaries of time and budget. The ten steps are research and information collecting, planning, developing preliminary form of product, preliminary field testing, main product revision, main field testing, operational product revision, operational field testing, and the last step is final product revision.

Data Collection Tools

Generic Science Skills Test

To determine students' generic science skills, generic science skill test was adapted and developed from Nature of Science Literacy Test (NOSLiT) by Wenning. It consists of 20 multiple-choice questions. It involves questions assessing generic science skill aspects developed by Brotosiswoyo (2009) that conducted ten aspects. There are direct and indirect observations, scale awareness, symbolic language, logical frame, logical consistency, casualty, mathematic modelling, concept constructing, and abstraction. Validity of the test gets score 0.75 which means the content of validity is good by using the Gregory formula. Therefore, the test was interpreted as valid and it was implemented to both control and treatment class groups as pre and post-tests. For the evaluation of scientific generic skills test, correct and wrong answers have been scored as 1 and 0 respectively.

Module Based on Discovery Learning

Students' generic science skills in treatment class group were assessed through module based on discovery learning developed by the researcher while in control class group were assessed through module commonly used in the school. Module based on discovery learning was conducted the activities using discovery learning syntax by Carin (1993). There are stimulation, problem statement, data collection, data processing, verification, and generalization. Validity of module based on discovery learning on the respiratory system matter to increase generic science skills is valid based on the average score of validation by experts. Module based on discovery learning gets score 88.3% by an expert of matter; 93.8% by an expert of module development; 100% by a linguist; 81.1% by an expert of a learning device; 85.6% by education practitioners; and 88.67% by students. Therefore, module based discovery learning on respiratory system matter to increase generic science skills was interpreted as valid and it was implemented to treatment class group.

Data Analysis

Difference between the pre and post test scores obtained from the control and treatment class groups have been analyzed. During the data analysis, parametric tests were used because the normality assumptions were fulfilled. In the analysis of the data, potential difference between control and treatment class groups before and after the module implementation in the learning process was assessed by using Independent Samples T-Test. After the learning process using module that commonly used in the school

and module based on discovery learning, between the control and treatment class groups, the difference between the pre and post test scores was analyzed by its N-gain. The criteria of gain index are presented in Table 1.

Table 1. The Criteria of Gain Index and Its Interpretation

Gain Index	Interpretation
$g > 0.7$	High
$0.3 < g \leq 0.7$	Middle
$g \leq 0.3$	Low

Result

Module Based on Discovery Learning on the Respiratory System Matter to Increase Generic Science Skills of Student

Module is developed by using six steps of discovery learning model syntax that was integrated with ten aspects of generic science skills. Module is divided into five chapters of the respiratory system subject. There are the structure and function of the human respiratory system, the breathing mechanism of human, the breathing frequency of human, the disorders or diseases of the human respiratory system, and the structure and function of the animal respiratory system.

Each chapter of module contain of the structured activity which is using discovery learning model syntax that was integrated with ten aspects of generic science skills. The first step of discovery learning is the stimulation that was integrated with an abstraction aspect, the second step is the problem statement that was integrated with a mathematic modelling aspect, next is the data collection step that was integrated with indirect/direct observations, scale awareness, symbolic language, and concept constructing aspects, and then the data processing step that was integrated with a logical frame aspect, the fifth step is the verification that was integrated with a logical consistency aspect, and the last step is the generalization that was integrated with a concept constructing aspect.

The percentage score of generic science skills in treatment and control class groups during the learning process are presented in Figure 1.

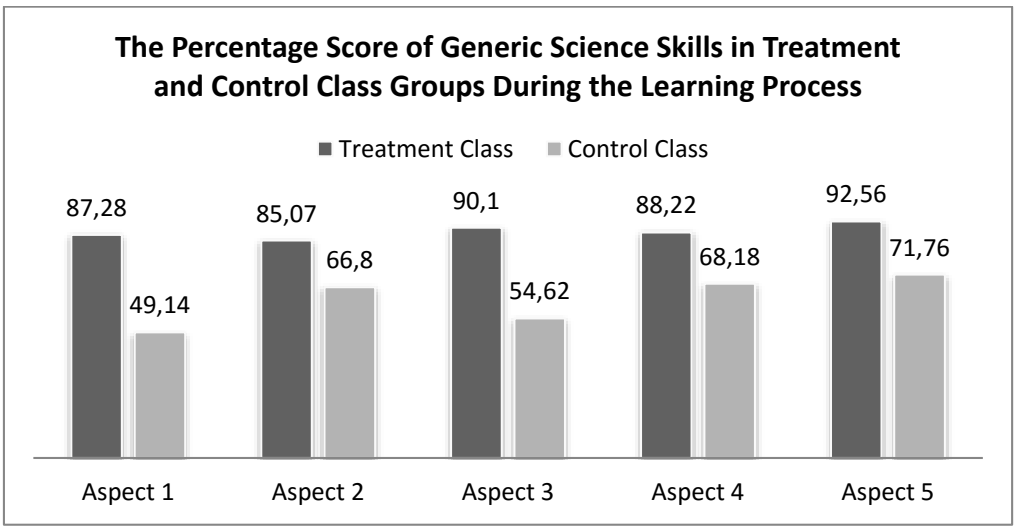

Figure 1. The Percentage Score of Generic Science Skills in Treatment and Control Class Groups during the Learning Process

Note:
Aspect 1 : Abstraction and mathematic modelling
Aspect 2 : Direct/indirect observations
Aspect 3 : Scale awareness, symbolic language, and casualty
Aspect 4 : Logical frame
Aspect 5 : Logical consistency and concept constructing

The aspects of abstraction and mathematic modelling get score 87.28% in treatment class and score 49.14% in control one. Score 85.07% for aspect of direct/indirect observations was got by treatment class and score 66.80% was got by control class. Next the aspects of scale awareness, symbolic language, and casualty in treatment class gets score 90.10% and control class gets score 54.62%. The aspect of logical frame gets score 88.22 in treatment class and 68.18% in control class. And the last is logical consistency and concept constructing aspects in treatment class gets score 92.56% and 71.76% for control class.

The Descriptive Analysis Result of Pre-test and Post test Scores in Treatment and Control Class Groups

The descriptive analysis result of pre-test and post test scores in treatment and control class groups are presented in Table 2 below.

Table 2. The Pre-test and Post test Scores of the Treatment and Control Class Groups

Class Group	Score	Range	Minimum Score	Maximum Score	Mean	N-gain		
						Min	Max	Average
Treatment	Pre test	40	30	70	54.17	0.33	1.00	0.69
	Post test	40	60	100	82.08			
Control	Pre test	50	30	80	52.50	0.14	0.50	0.26
	Post test	40	40	80	63.34			

The pre-test and post test scores in treatment and control class groups showed in Figure 2 below.

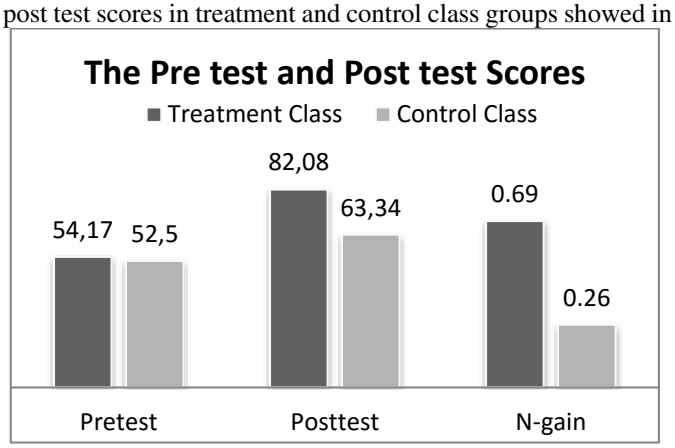

Figure 2. The Pre-test and Post test Scores in Treatment and Control Class Groups

Based on Table 1 and Figure 2, it can be seen the average score of pre-test in treatment class and control class is not much different, where the pre-test score average of each class are respectively 54.17 and 52.50. The results of the post-test as presented in Figure 2 can be seen that the average score of post-test in treatment class is higher than the control class, where the post test score average of treatment class is 82.08 with N-gain score is 0.69 (middle criteria) and the post test score average of control class is 63.34 with N-gain score is 0.26 (low criteria).

Discussion

Module based on discovery learning at the respiratory system subject is effective to increase students' generic science skills significantly. The effectiveness of module is evidenced with the increasing of generic science skills post test score after learning by using a module based on discovery learning. The increasing of generic science skills post-test was calculated by the score of the N-gain. Based on the analysis as presented in Table 2 shows the average N-gain of generic science skills in treatment class is higher than the control class, that is 0.69 which is included to the middle criteria.

According Kulldel (2007) states that the use of teaching modules to improve student achievement should be widely used in various grade levels of education. Jew (2012) adds learning through discovery learning can improve the mastery of materials, retention, and transfer of knowledge and learning are more significant. Therefore it is necessary to analysis the learning result in the form of knowledge, attitudes, and skills as supporting data. The results of experimental class learning has increased at each meeting and the results of the average tends to be higher than the results of the control class as presented in Figure 1. This is supported by Rohim, et al. (2012) which mentions that the model of guided discovery is more effective in learning science, because this model helps students meet two important criteria in active learning that builds knowledge to make sense of new information and integrate new information to find the proper knowledge.

Based on the results of the activity in the module that presented in Figure 1, it shows that the activities students did with using syntax of discovery learning can train generic science skills aspects to students. The learning using discovery learning model by Anders (2012) allows the students can explore, find out, and find themselves in the learning process, so that students take an active role to create, integrate, and generalize knowledge. Eaton & Whittle (2012) adds generic skills required for success in a wide range of activities in education and training, work and life in general. Osman, et al. (2009) states the importance to insert 21st century thinking skills in the learning process and generic science skills can train those 21st century thinking skills. Zainal, et al. (2012) states the generic skills are the increasingly important skills in life, especially in this era of globalization. These skills will give advantages to individuals especially to the graduates who will be graduating and will be involved in future work.

Module based on discovery learning that are used in the learning process can increase students' generic science skills because in the module presented the activities are structured in the form of experiments and observations by using the syntax of discovery learning where every aspect of discovery learning is integrating with aspects of generic science skills. Sulistyowati, et al. (2012) concludes that the application of guided discovery learning model is effective against the problem solving skills of students. And then Purwanto, et al. (2012) concludes that the application of guided discovery learning model can improve students' critical thinking skills. Furthermore, Fathur, et al. (2012) concludes that the application of guided discovery learning model can improve students' creative thinking skills. Aspects of problem solving, critical thinking, and creative thinking skills is the aspect of high-level thinking skills which these three aspects are part of the components of generic science skills. Star & Hammer (2008) discusses the critical thinking and problem-solving as an integral part of the generic skills.

Overall based on the results of the analysis have shown that the use of module based on discovery learning on respiratory system matter is more effective in increasing students' generic science skills. Tricot & Sweller (2014) states that the generic science skills will produce students who are able to understand the concept and it can teach problem-solving strategies to them. It supported by Hockey, et al. (2010) states that the generic skill includes the ability to communicate as well as troubleshooting. Further Badcock, et al. (2010) states that the components of generic skills include critical thinking, problem solving, interpersonal skills, capacity to think logically and independently, communication and information management capabilities, curiosity, creativity, and integrity. McHaney (2012) states that the discovery learning is an instructional model that involves students in the exploration and problem solving to create, integrate, and filter knowledge, and students can learn and advance at their own pace to build a meaningful new knowledge.

Conclusion

Module based on discovery learning is effective to increase generic science skills because a statistical analysis test results showed significant differences between the posttest control class group which using a module that commonly used in the school with treatment class group which using a module based on discovery learning.

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