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THE ANALYSIS OF STUDENTS SCIENTIFIC REASONING ABILITY IN SOLVING THE MODIFIED LAWSON CLASSROOM TEST OF SCIENTIFIC REASONING (MLCTSR) PROBLEMS BY APPLYING THE LEVELS OF INQUIRY

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ABSTRACT

This study aims to determine the students' achievement in answering modified lawson classroom test of scientific reasoning (MLCTSR) questions in overall science teaching and by every aspect of scientific reasoning abilities. There are six aspects related to the scientific reasoning abilities that were measured; they are conservatorial reasoning, proportional reasoning, controlling variables, combinatorial reasoning, probabilistic reasoning, correlational reasoning. The research is also conducted to see the development of scientific reasoning by using levels of inquiry models. The students reasoning ability was measured using the Modified Lawson Classroom Test of Scientific Reasoning (MLCTSR). MLCTSR is a test developed based on the test of scientific reasoning of Lawson's Classroom Test of Scientific Reasoning (LCTSR) in 2000 which amounted to 12 multiple-choice questions. The research method chosen in this study is descriptive quantitative research methods. The research design used is One Group Pretest-Posttest Design. The population of this study is the entire junior high students class VII the academic year 2014/2015 in one junior high school in Bandung. The samples in this study are one of class VII, which is class VII C. The sampling method used in this research is purposive sampling. The results showed that there is an increase in quantitative scientific reasoning although its value is not big.

Keywords: scientific reasoning; MLCTSR; levels of inquiry; science

INTRODUCTION

Science (IPA) related to the natural way of finding out about a systematic manner so that IPA is not only a mastery of a collection of knowledge in the form of facts, concepts or principles but also a process of discovery (Allson in PMP IPA, 2014). Thus, students are trained to be able to find their various concepts studied thoroughly (holistic), meaningful, authentic, and active. One of the purposes of learning science is the development of scientific reasoning ability.

Scientific reasoning is important for science, but the research by Koslowski (1996) indicated that many steps in the inquiry which is intended for scientific reasoning did not reflect the core attributes of scientific reasoning itself. Thus, scientific reasoning should be developed in students through the practice of scientific reasoning in a longer period and the more appropriate inquiry approach. (Chinn & Malhotra, 2002). Reasoning in problem-solving is to be developed in learning (H. Bancong, Subaer, 2013).

National Science Teacher Association and Association for the Education of Teachers in Science / NSTA & AETS (1998) stated that inquiry as for the development and use of higher order thinking. Scientific reasoning belonged to

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the high-level thinking skills related to the ability to identify, analyze and solve problems creatively and think logically so as to produce the proper consideration and decision; so that the scientific reasoning can be developed with the inquiry.

Based on direct observation in a junior high school in Bandung, it can be said that the purpose of learning science to develop scientific reasoning is less achieved. It is based on the findings of the following: 1) The results of the interview, conducted by one of the science teachers stated that classroom learning is not based on inquiry as a whole because it is still rare to experiment with, other than that there is difficulty in developing scientific reasoning because the type of questions used is still in the form of memorization and quantification, without ever trying to use standardized tests. So it did not require students to think higher and tend just to memorize formulas. Occasionally, the inquiry is conducted in learning but not fully engaged students in scientific inquiry and plan an experiment. Whereas, the scientific investigation and knowledge content are interconnected to underlie the development of scientific thinking. 2) The result of observations, made in the same school showed that the learning did not facilitate the development of scientific reasoning because, during the learning process, it has not been emphasized on the argumentative student's skills so that the students are less able to express their ideas. Besides, the learning process is focused on the delivery of content verbally and then write down the things that are considered important in the board. Although sometimes there are questions and answers in learning activities, only a few students that are actively involved. Also, the learning activities are rarely associated with the material being studied by its application in everyday life. So that students can develop skills that can be used outside the classroom, such as decision-making and problem-solving.

So, based on the results of the preliminary studies, it can be concluded that the learning activities have not been able to facilitate the development of scientific reasoning, especially in training and measuring appropriately. It causes the students unable to construct their knowledge independently so that the students' knowledge is less meaningful. Whereas, when students construct their knowledge, the learning will be more meaningful and can be remembered in the long run. Also, students are only able to solve problems and make decisions about the material being taught without being able to relate it to the application of the material. It causes the scientific reasoning ability of students to be low. The essence of current IPA education reform is the shift from traditional teaching, low-level algorithmic thinking skills to learning that spur high-thinking skills such as reasoning (Rustaman, 2007). The development of reasoning ability and analytical thinking of students can be facilitated by the creativity of the teacher in developing the learning model (Saptono, et al., 2013).

An alternative solution that considered to solve the problem is by applying the inquiry model. Wenning (2005) explained that systematically inquiry affects the more effective process of knowledge transfer. Based on the background that has been disclosed above, the researchers are interested to know the development of scientific reasoning on integrated science learning using systematic inquiry model which is the levels of inquiry. The levels of inquiry models consist of six levels, started with the basic level to the highest level. These levels are discovery learning, interactive demonstrative, inquiry lesson, lab inquiry, real-world application and hypothetical inquiry (Wenning, 2010).

Scientific reasoning is defined as the students' cognitive abilities in five dimensions: serial ordering reasoning (students' ability in ordering data), theoretical reasoning (students' ability in applying theories to interpret data), functionality reasoning (students' ability in analyzing functional relation), control variables (students' ability to control variables), and probabilistic reasoning (students' ability in predicting based on data) (N. Shofiyah, 2013). Reasoning will support the use of information that was already obtained by students with information and commands in the matter of producing answers that reflect the mastery of related concepts (Nurdjani, 2012). The scientific reasoning referred to in this study is the ability to think and provide a reason through the activities of inquiry, experiment, drawing the conclusion based on facts and argument to compose and modify a theory about nature, as well as social (Bao et al., 2009). Scientific reasoning references used in this study are found in the Lawson framework which includes six aspects, namely the reasoning measured by conservatory reasoning, proportional reasoning, controlling variables, combinatorial reasoning, probabilistic reasoning, correlational reasoning (Lawson, 1994). However, the reasoning framework used in this study is the result of its development formulated by Jing Han (2011). The student reasoning abilities are measured using the Modified Lawson Classroom Test of Scientific Reasoning (MLCTSR). MLCTSR is a test developed based on a scientific reasoning test from Lawson's Classroom Test of

Scientific Reasoning (LCTSR) in 2000.

There are 24 double choice questions of two levels on LCTSR (Jing Han, 2011). Researchers modified it by the content based on the concept of science that is the motion that is tailored to the LCTSR assessment framework. However, the researchers only made 12 questions by the LCTSR indicator due to the results of discussions with the classroom teachers who did the teaching and asked to cut 24 questions into 12 without eliminating the aspect of scientific reasoning. This test is done twice on pretest and posttest.

The distribution of questions on each aspect used is based on the results of the development of the instrument; it can be seen in the table below:

Table 1. The Distribution of Questions on Each Aspect

Scientific Reasoning Aspects	Questions Number
Conservation of matter and volume	1,2
Proportional reasoning	3,4
Control of variable	5,6
Probability Reasoning	7,8
Deductive reasoning	9,10
Hypothetical-Deductive Reasoning	11,12

METHODS

The determining of research method is based on the formulation of the problem and the purpose of research to be achieved. The research method chosen in this research is quantitative descriptive research method. This study described all activities, conditions, events, aspects of the component as they are and their picture using size or frequency. The only element of manipulation or collecting of the data provided is the study itself, which is done through observations, interviews, questionnaires or documentation studies (Sukmadinata, 2012: 73). Descriptive research not only stops on data collection, organizing, analyzing, and withdrawing interpretations and conclusions, but proceeds by benchmarking, seeking similarities, differences, causal relationships of various things because the discovery of meaning is the focus of the whole process. (Best, 1970, p. 117).

This study did not manipulate or alter the free variables but described a condition as it is. The depiction of conditions can be individual or group, and use the numbers. The research design used is One Group Pretest-Posttest Design. In this design, there is no comparison or control group (Creswell, 1994, p. 130). Also, there is a pretest before the collecting of data so that the results of data collection can be known accurately because it can be compared before and after being given data.

The location used in this research is one of Junior High School (SMP) Negeri in Bandung. The reason the researchers chose the location because the school has a decent laboratory equipment, experimental tools in the school is quite complete and has been reacted for A, so researchers assumed the school is suitable for data collection.

This study aims to determine the development of scientific reasoning of junior high school students in integrated science learning by using the level of inquiry model. Therefore, the population in this study is all students of class VII SMP academic year 2014/2015 in Bandung. But due to the limited fund, human resources and time, the researchers only took samples from the population. The sample of this research is one of class VII that is class VII C.

The sampling method used in this research is nonrandom sampling that is the collection of sampling that did not give same chance for every member of the population to be selected to become the member of samples (Fraenkel, J.R, 2012, p. 94). The sampling technique used is purposive sampling that is taking the sample members of the population which are done with certain considerations.

Some of the considerations used as the reason for selecting the samples were recommendations from the teachers at the research location who knew the condition of the students that suggested the more easily conditioned classes and the students that were more active in learning. Their intelligent levels selected the students from 10 classes of the population based on their marks as a material for determining the samples. Then, the class that has the highest average score was selected as a representative sample.

In this study, all the problems of scientific reasoning used were derived from standardized tests, so that in the adaptation must be tested in advance to obtain a valid and reliable instrument. The test instrument analysis included the tests of validity, reliability, difficulty, and distinguishing. The test of the research instrument using states v4. Arif (2014) stated that states are an application program developed by Drs.Karno M.Pd and Yusuf Wibisono, ST that can calculate the analysis of questions quickly, easily and accurately, let alone this application used Bahasa. States is capable of displaying several features and calculations including weighted data scores, test reliability, upper and lower groups, distinguishing power, difficulty level, correlation of question score with total score and quality of checkers.

The results of instrument experiment using rates from 12 questions that were used with the correct weight score are 1, and the weight of the wrong score is 0, then the average student score is 6.00, with a standard intersection of 1.89. The correlation of XY is 0.60, and the test reliability is 0.75.

RESULTS AND DISCUSSION

The students' scientific reasoning can be known quantitatively and qualitatively. Quantitatively, students' scientific reasoning is shown based on the pretest score and posttest score obtained by the students. While qualitatively, students' scientific reasoning is assessed in each sub-subject (each meeting) which emphasized the process from beginning to end in stages.

Scoring on scientific reasoning tests based on the scoring of tests made by Lawson (1994) is by way of the pair scoring schema. In this scoring, if students answered correctly between the content and the reason was given score 1. The scoring indicated that the students who were able to answer correctly between the content and the reason were considered to be able to solve the questions properly. If there is an error in the answer given either on the content or the reason, then the score is 0 and students were considered to be not able to solve the questions. Based on the scoring used, the student answers can form a pattern. There are four existing patterns, they are 1.1; 1.0; 0.1 and 0.0 patterns.

On Lawson's classroom test of scientific reasoning, combinatorial reasoning is replaced by correlational reasoning and hypothetical-deductive reasoning. This test is converted into a pure multiple-choice format containing 24 questions or 12 pairs between answers and reasons, so there are four questions for each aspect. In the original test, it can be seen the consistency because there are two pairs of questions for the same aspect with different numbers. In this study, scientific reasoning tests consisted of only 12 questions or 6 pairs. So, there is one question in the form of content and reason for every aspect of reasoning.

There is not found consistency in every aspect of scientific reasoning in this study. Therefore, the scientific reasoning scores are only one pattern, which is (1,1), (1,0), (0,1) or (0,0) without any pattern repetition in every aspect of scientific reasoning. So, the pattern of answers given by the students can not be compared with the findings of Jing Han (2011) which showed the level of consistency between questions and reasons. However, it still can be seen the image of scientific reasoning in every aspect without involving its consistency.

Student's scientific reasoning on the subject of linear motion can be determined by knowing the average value of pretest and posttest. Only the gain is used not with the effect size because there is no treatment in the research to see the increase. Meanwhile, to know the development of scientific reasoning is determined by the assessment of each meeting from the beginning of the data until the end, i.e., on the sub-subject of the irregular linear motion.

The students' scientific reasoning is obtained based on their reasoning patterns for both pretest and posttest that is presented in the following diagram.

Based on the diagram it can be seen that in the pretest and posttests, the 0.0 pattern still dominated to be the highest, while pattern 1.1 is below the percentage of the pattern 0.0. It indicated that the pretest and posttest of the majority of students have not been able to answer the reasoning questions and its reasons correctly. For pattern 1.0 or one that answered correctly but wrong on the reason is more than the 0.1 pattern which did not answer correctly but got the right reason. The existence of students who answered the questions correctly but wrong on the reason or otherwise indirectly stated that there is a problem with the way students answer the questions.

The scientific reasoning can be seen as a whole from the pattern of 1.1 which showed the ability of students in solving the problem proper-

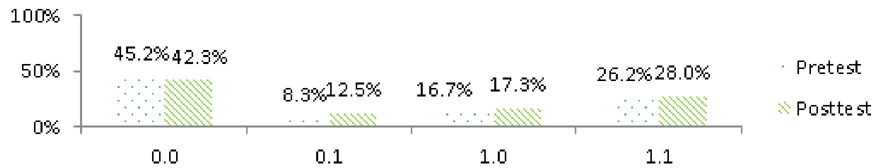

Figure 1. The Students' Answers on Scientific Reasoning Test Instrument

ly, it can also be seen from the average score of the students on pretest and posttest. Below it will be presented a figure of scientific reasoning on motion material. The percentage based on pattern 1.1 is as follows.

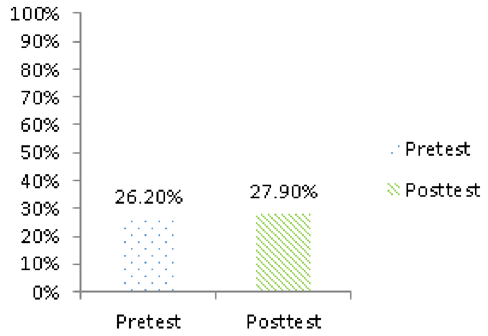

Figure 2. The Percentage Diagram of Scientific Reasoning

Based on Figure 2, the information obtained that the percentage of scientific reasoning with the 1.1 pattern only increased by 1.7%. It meant a small increase. In addition to the data above, the following will present a diagram of scientific reasoning based on the average posttest and pretest scores.

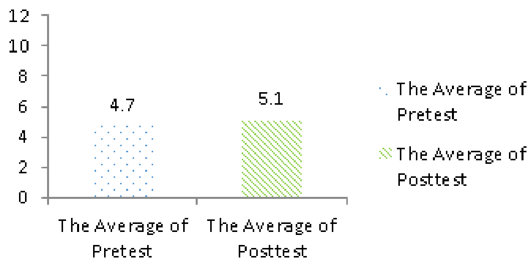

Figure 3. The Scientific Reasoning Diagram Penalaran Based on the Averages of Pretest and Posttest

Based on Figure 3, it is also obtained information that the scientific reasoning only has a difference of 0.4. So, it can be concluded quantitatively, either based on the 1.1 pattern or based on the average pretest and posttest score, there is an increase, but only a small increase. Because it only has a small difference too. The picture of the percentage of every aspect of scientific reasoning using pattern 1.1, in general, can be presented in the following diagram.

Based on Figure 4, it is found that the percentage of every aspect of scientific reasoning for pretest and posttest has different scores. There is a gain percentage 1.1 on pretest higher than posttest, but there is also the opposite. The higher percentage gain of 1.1 in the pretest is control of variable and probability. It showed the problem of students in answering and solving the problems in the aspect of reasoning. As for the acquisition of a higher percentage of 1.1 in posttest is conservational weight, proportional reasoning, and correlational reasoning. As for hypothetic-deductive reasoning has the same number for the 1.1 pattern on pretest and posttest.

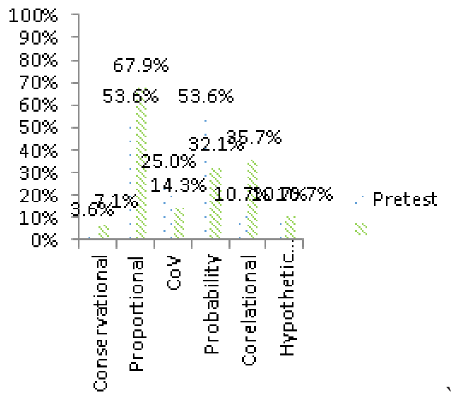

Figure 4. The Diagram of Scientific Reasoning Percentage on every Aspect

Quantitatively, the increase in scientific reasoning can be seen based on two components, namely the overall pattern of 1.1 and based on the difference in the average score of students. Based on the overall 1.1 pattern there is an increase in scientific reasoning ability of 1.7%, while based on the average score of students is 0.4. Although the increase is not large this indicated a change from before data collection, and after data collection, this did not indicate the treatment because students have previously used levels of inquiry.

Gradually, however, students continued to be trained with the levels of inquiry to improve their scientific reasoning. The increased scientific reasoning may be due to the students who have accustomed to the discovery-based learning so that they began to be able to construct their knowledge by using the level of inquiry model. It is in line with Wenning's expression (2011, p 17) which stated that:

"The level of inquiry models of science teaching is an approach to instruction that systematically promotes the development of intellectual and scientific process skills by addressing inquiry in a systematic and comprehensive."

If viewed by the level of inquiry in the classroom that almost all activities were done and the active involvement of students based on the learning video can be another factor of the increase. Because students actively observed, defined variables and relationships, conducted experiments, communicated observations and made conclusions so students can construct knowledge independently.

If viewed on the percentage of students' scientific reasoning in every aspect, then the highest overall aspect is proportional reasoning while the lowest aspect is conservatory of weight. In the pretest, the highest aspect is proportional reasoning, as well as on the posttest. The lowest aspect is conservational of weight both on pretest and posttest. It can be attributed to the stages of levels of inquiry that has been trained, the proportional reasoning is an interactive demonstration, in which teachers were tasked with demonstrating, developing and asking questions, generating responses, asking for explanations so as to help students reach evidence-based conclusions. At this stage, the students have started to have a role based on real evidence of demonstration by the teachers. In contrast to the conservation of weight aspects trained in the early stages which is the discovery learning. The primary focus of discovery learning is to construct an inductive concept or knowledge acquired from the students' experience. At this stage, students have different experiences. It may be that the phenomenon at this stage is less appropriate to the students' experiences, or even the students have different experiences with the given presentation. Also, there may be difficulties for students to identify the relation between the phenomena given and their experiences.

The development of scientific reasoning required a lot of practice and patience because scientific thinking is a complete set of cognitive skills. It is critical for both teachers and researchers to understand how scientific skills developed. It can be seen where the percentage of LKS is just above 75% until the third meeting and not yet reached 80 even 90%. It indicated the development of students' scientific reasoning is also not maximally analyzed at the end of the meeting as the posttest. It is in line with the idea of Lawson (1979) which stated that the developmental view of intelligence, that intelligence is not only innate but how the ability of students' reasoning develops.

The development of scientific reasoning referred to a process or way of learning that built the students' knowledge of a particular concept that evolved over time. At the first meeting, basic ideas about the meaning of motion were developed with the levels of inquiry model with labs to build their knowledge independently. At the first meeting, scientific reasoning on the conservational weight and proportional aspects are on score 8.7 which is trained with discovery learning and interactive demonstration. This score decreased at the second meeting. It is not a very important issue because at the third meeting there is an increase again. Neither did the other aspects of reasoning. Various problems arose because of the lack of time to examine the developments which take a long time because the process of development is repeated to determine the progress of learning because advances in learning will not occur naturally and required instruction.

Researchers have only three meeting times to collect the data by the time agreement given by the school, and this time is not enough to see the development of scientific reasoning over and over again. Besides, describing the development of scientific reasoning is not an easy thing because each student learned in different ways, only the general nature of the learning progress that can be used as research evidence. It is in line with Jing Han (2011, p. 118).

"To define a scientific reasoning learning progression, more work is needed. Defining a learning progression is not an easy task, particularly because each student learns in a different way but a common trait among learning progressions is that they are designed based on research evidence. "

CONCLUSIONS

Based on the results of data analysis and discussions, it can be concluded that quantitatively there is an increase in scientific reasoning although the score is not high. The increase of scientific reasoning may be due to students being familiar with the discovery-based learning so that students began to be able to construct their knowledge by using the level of inquiry model.

The writer recommends several things, including 1) For teachers: the levels of inquiry model can be used as an alternative learning to train the scientific reasoning so that the students can construct their knowledge independently). For other researchers: It would be better if the instrument of scientific reasoning test is made to be four questions of each aspect so that it can be seen its consistency, 2) To be able to develop scientific reasoning takes a long time. Thus, the greater the learning pattern applied, the more scientific reasoning will develop.

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