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Abilities of Reasoning and Mathematics Representation on Guided Inquiry Learning

Yumiati [*]
Universitas Terbuka

Mery Noviyanti [**]
Universitas Terbuka

Abstract

This research initiated by some research result regarding the lower Reasoning and Mathematics Representation of student on the math learning. In order to upgrade the abilities is passing through the guided inquiry learning. The aim of the reasearch is to analyze comprehensively on accomplishment reasoning and math representation of student who gain the guided inquiry learning and conventional learning. The research is applying experiment method by design of one group pretest-posttest. The result of research indicates the guided inquiry learning is more effective in accomplishment and improvement of student representation capabilities and student comprehend compared with the conventional learning. Reasoning and Mathematics Representation of group student or guided inquiry learning is higher from the group student of conventional learning. The improvement of Mathematics Reasoning of Group Student of guided inquiry learning values 0.33 on the medium category, while the improvement of Mathematics Representation of group student of conventional learning values 0.19 on the low category. The amount of improvement on Mathematics Representation of group student of the guided inquiry learning is 0.41 on the medium category, and the improvement on Mathematics Representation of group student of conventional learning is 0.26 is on the low category.

Keywords: *Reasoning, Mathematics Representation, Guided Inquiry Learning*

[*] Yumiati, Universitas Terbuka, Jl. Cabe Raya Pondok Cabe Pamulang Tangerang, Indonesia
E-mail: *yumi@ecampus.ut.ac.id*

[**] Mery Noviyanti, Universitas Terbuka, Jl. Cabe Raya Pondok Cabe Pamulang Tangerang, Indonesia
E-mail: *meryn@ecampus.ut.ac.id*

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Introduction

Math equipped students to deal with world challenge, which was more growing, and as one tool used was reasoning. This matter was suitable with the statement of Ayalon & Even (2010), namely math served students a group of unique powerful tool to comprehend and to change the world. These tools scoped logically reasoning, problem solving ability and abstract thinking ability. Boulton-Lewis & Tait, 1993; Verschaffel, 1994; Outhred & Saradelich, 1997; Diezmann, 1999; Swafford & Lan-grall, 2000; Diezmann & English, 2001 (in the Panasuk, 2011) stated that symbol and representation system were very crucial for math as one science discipline because representation referred to abstraction forming and math science demonstration, as well as illustration of math problem solving situation. Using the different methods from representation and relation, which described early point within math education where students used one symbolic system for extending and comprehending the others (Anastasiadou, 2008).

Based on the above outline, apparently, reasoning or math was highly required within math learning. However, in the other side, problem still were found on both abilities based on some research outcomes. Priatna's research outcome (2003) expressed that reasoning ability quality (analogy and generalization) of junior high school student was low, which only 49% of ideal score was. Likewise, Napitupulu's research outcome (2011) stated that entirely math reasoning ability of students still be classified as lower level. The lowest accomplishment of reasoning ability upon the aspect provided explanation upon model, fact, character, relation or existing pattern.

In relating with math representation ability of students, it was found that math representation ability of students still had problem, particularly in translating from graphic to verbal and from table to verbal, as expressed by Anastasiadou (2008). Ozyildirim's research outcome, *et.al.* (2009) stated that the easiest translation, apparently, it was translation from diagram's representation to algebra, meanwhile the most difficult translation was from table representation to algebra. The problem found relating with student representation ability for example as follow. When students were questioned: *"s and t were two numbers and s was eight more than t. Wrote down the equation indicated a relation between s and t".* Most student answered "$s + 8 = t$". It showed that students still had a weakness to change from verbal to algebra representation.

In order to upgrade student mathematical reasoning and representation ability, it was necessary to done math learning which gave student opportunity for reasoning and solving problem independently. According to Suryadi (2005), math learning was more emphasizing on reasoning and problem-solving aspects, which enable to produce high performance students on math test, conducted by TIMSS, like in Japan and Korean.

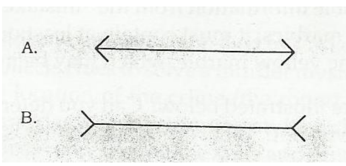
Learning qualified above characters was inquiry learning. Gulo, as quoted by Trianto (2010), stated that inquiry strategy meant that a sequence of study activities which involved entire students ability maximally to seek and to inquiry systematically, critically, logically and analytically, so that they could formulate their own invention by fully confidence. Hereby, student mathematical reasoning and representation ability would be trained. Suitable inquiry learning to junior high school student still needed a study with dominantly teacher guidance was guided inquiry learning.

Mathematical Reasoning

The term reasoning is defined as the process of reaching logical conclusion based on facts and relevant sources (Shurter and Pierce, 1966; within Afgani, 2011). According to Baroody (1993) reasoning in mathematics is divided into 3 types, which are intuitive, inductive, and deductive reasoning.

Intuitive Reasoning

Intuitive reasoning is the process of making decision or conclusion that is only based on intuition without using the required information. For example, look at the picture of the two line segments.



Intuitively, line segment B is longer than line segment A. But in fact in mathematics, line segment A is longer than the line segment B.

Inductive Reasoning

Inductive reasoning involves the observation of regularity (heuristic of finding patterns in problem solving involves this type of reasoning). The finding of a general rule among diverse examples is the basis in formulating concepts or principles. For example, to determine the sum of the first n odd natural numbers is as follows:

$$
\begin{aligned}
1 + 3 &= 4 &&= 2 \times 2 \\
1 + 3 + 5 &= 9 &&= 3 \times 3 \\
1 + 3 + 5 + 7 &= 16 &&= 4 \times 4 \\
1 + 3 + 5 + 7 + 9 &= 25 &&= 5 \times 5
\end{aligned}
$$

From the patterns above can be concluded:

$$1 + 3 + 5 + \ldots + 99 = 50 \times 50 = 2.500$$
$$1 + 3 + 5 + \ldots + (2n - 1) = n^2$$

The patterns above form a principle in which the sum of the first n odd numbers is n^2.

Deductive Reasoning

Conclusion drawing in deductive reasoning is based on the existing rules. Donaldson, 1978 (in Baroody, 1993) said that a conclusion that is drawn deductively means "giving certain information, and we believe the other things" that may or may not be examined directly. For example, there is a principle that for every number $a \in \mathbb{R}$ (real numbers), then $b \in \mathbb{R}$ is exist such that $b > a$. Thus, we can conclude that there is no biggest number, or the number does not end until infinity.

Mathematical Representation

Goldin & Shteingold (2001) divided the representation into two systems, external and internal representation system. External representation is a kind of signs or symbols, characters, or object to symbolize, depict, encode, or represent something other than itself. External representations can be: 1) notation and formal, such as the number system, algebraic notation, equations, function notation, derivative, and integral calculus; 2) visual or spatial, such as the number line, Cartesian graph, polar coordinate system, box plots of data, geometrical diagrams, and computer-generated images of fractals; and 3) the words and sentences, written or spoken. Figure “5” is an external representation sample that can represent a set consisting of five objects, or may also represent the location or the result of the measurements. Cartesian graphs can describe the data set, or it can represent a function or solution set of algebraic equations. Thus, one thing can represent many things.

Guided Inquiry Learning

Inquiry learning according to Alberta Learning (2005) is a process in which the students are engaged in their learning, formulating questions, investigating widely and then creating understanding, meaning and new knowledge. Through those activities, students will create or construct understanding, meaning and new knowledge. This is in compliance with constructivism theory that all the knowledge we gain is acquired by ourself.

Sund, Trowbridge, and Lieslie (Gani, 2001) divided inquiry learning into three types, according to the magnitude of the intervention or guidance from teachers to students, which are: a) Guided Inquiry: students get guidance from their teacher to understand the concept, then students independently complete the relevant tasks by having discussion or individually; b) Free Inquiry: students are free to determine the problem to be observed, to find and to resolve the problem independently by designing the procedures or steps required with limited or no guidance from their teacher; c) Modified Free Inquiry: collaboration or modification of guided inquiry and free inquiry method. Guidance provided by the teacher to the student is less than that of guided inquiry model and is unstructured. Based on the definition and description of the three types of inquiry methods mentioned above, Guided Inquiry type is allegedly more appropriate to be applied to junior high school students.

Relation between The Guided Inquiry Learning with Reasoning and Math Representation Ability

Risnanosanti (2010) said that inquiry learning firstly developed and had an objective to involve students in reasoning process regarding causal relation and caused them more fluently and precisely in submitting any question, developing concept and formulating as well as testing hypothesis. Furthermore, Wahyudin (2008) said what mostly abandoned within inquiry learning were facts that steps within inquiry learning included two thinking process. Problem definition and hypothesis submitting involved inductive discovery. Within data collection, implementation and solutions testing, someone entered into deductive proof. Therefore, it was definitely that such problem solving benefited thinking process of inductive and deductive, although it was naturally assumed that inquiry only benefited inductive processes.

From the above explanations, it could be drawn any conclusion within inquiry learning, student reasoning ability always be trained and thus, student math reasoning could upgrade through inquiry learning. According to Farmaki & Paschos (2007), through empirical materials of progressive mathematical, student could improve graphic representation models to manipulate images concept that could led them to fulfil their needs on formal math argumentation. This statement also signalled when someone conducted reasoning activity, then representation systems would work to produce any argument or conclusion. Thus, it was assumed that the upgrade of student math representation ability could also cause student representation ability was upgraded. Thus, it could be assumed that through inquiry learning, student mathematical reasoning and representation would also be upgraded.

METHOD

The Research Subject is students of Dharma Karya UT Middle School at 8th Grade. Selecting for Middle School student as subject conducted according to the following considerations. Middle School students are having 11-16 years old. According to Piaget, children on these ages already had formal or abstract mind level. This matters suit with the reasoning and representation refer to abstraction forming. In addition to that, the implementation of guided inquiry learning is most appropriate to be implemented for Middle School student, considering that Middle School student still need dominantly guidance within session learning.

Selecting for 8th Grade by considering as follow: 1) students at this class have been more homogeny within their basic competencies; 2) students at 8th grade have not been undergoing National Examination (UN) so that it wouldn't disrupt their preparation; 3) students at 8th Grade have been more adapted with new school environment (from Elementary up to Middle School) compared with student at 7th Grade.

Dharma Karya UT Middle School has four 8th grade. From these four grades, it is selected randomly one grade for limited trial, and two grades for wider trial. It is selected 8-4 for limited trial, while for wider trial; it is selected 8-2 and 8-3 grades. 8-2 grade selected as control grade and 8-3 grade selected as experiment grade. Numbers of research subject on trial level presented within Table 1.

Tabel 1. Research Subject on Trial Level

Trial Level	Grade	Student Numbers	Group
Limited	8-4	19	Trial
Wider	8-3	20	Experiment
	8-2	19	Control

RESULT AND DISCUSSION

The purpose of this research is to comprehensively analyze differences in achievement and improvement of reasoning ability and math representation of students who got a guided inquiry learning and who received conventional learning. In addition, more extensive trial models also used to know the criteria for improvement of reasoning ability and math representation students included into the category of high, medium, or low based on the criteria proposed by Hake (1999). The achievement reasoning ability and math representation seen based on the average post-test, whereas the increase reasoning ability and math representation students seen by the average N-gain.

The research design used in the trials wider models is pretest posttest with control-group design. The trial conducted in junior models Dharma Karya UT. There are two classes sampled, namely experiment class by applying the guided inquiry learning, and classroom control by applying conventional learning. The number of students in the experiment class is 20 people, and 19 people in control class. Before and after teaching at both classes are given reasoning ability and math representation test

Descriptive analysis of each capability presented in the following Figures. The Figure presents pretest data image, posttest (achievement), and N-gain reasoning ability students.

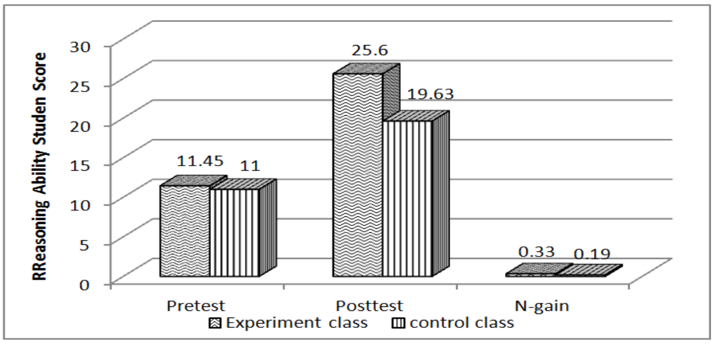


Figure 1. Pretest, posttest, and N-gain reasoning ability students

The Figure 1 shows the average pretest reasoning ability students are relatively similar between the experiment class students and control class. However, after learning, it acquired that reasoning ability posttest scores at experiment class student is higher than the control class. N-gain of reasoning ability experiment class student is 0.33 including medium category, while N-gain of reasoning ability control class student is 0.19, which included as low category.

Data relates with the pretest, posttest (achievement), and N-gain math representation ability students presented in the following Figure 2.

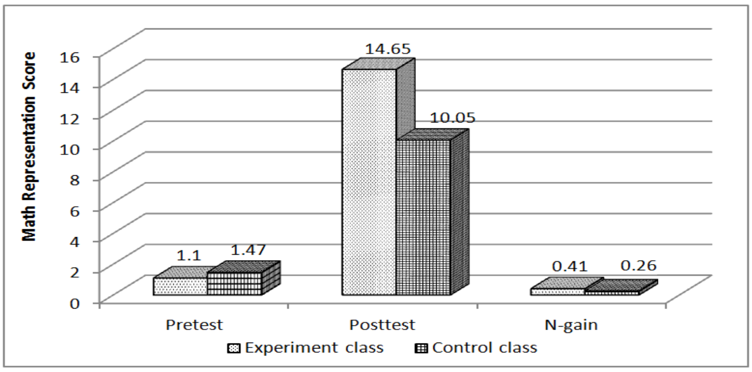


Figure 2. Pretest, posttest, and N-gain math representation ability students

Based on Figure 2 indicated that the average pretest students of math representation relatively similar between the experiment class students and control class student. However, after learning math representation posttest scores, obtained that experiment class students is higher than the control class. N-gain of math representation experiment class student is 0.41 including medium category, while N-gain math represeantation control class student is 0.26, which included as low category.

Table 2. T-test result on reasoning ability pretest control class and experiment class

Data Type	*N*	Average	*T*	*df*	*Sig*.(2-ways)	H_0
Reasoning ability control pretest	19	11,00	0,223	37	0,825	Received
Reasoning ability experiment pretest	20	11,45				

The t-test result (Table 2) of reasoning ability pretest student shows that reasoning ability pretest between the control and experimental class students did not differ significantly. It can be said that the beginning reasoning ability student is similar for both classes, so if any difference in the final score of reasoning ability by the end of learning can be caused any influence of the learning model.

Tabel 3. T-test result on reasoning ability posttest and N-*gain* Control and Experiment Class Students

Data Type	*N*	Average	*t′*	*df*	*Sig*.(2-ways)	H_0
Reasoning ability control posttest	19	19,63	2,316	28,234	0,028	Rejected
Reasoning ability experiment posttest	20	25,60				
N-*gain* of reasoning ability Control	19	0,19	2,820	27,563	0,009	Rejected
N-*gain* of reasoning ability experiment	20	0,33				

T- Test result (Table 3) on posttest data and N-gain of reasoning ability student shows that whether posttest as well as N-gain of reasoning ability between the control and experimental class students is difference significantly. Posttest and N-gain experimental class is higher than the control class. In other words, guided inquiry learning influences on student achievement and improvement reasoning ability.

The research result shows that reasoning ability students' achievement on the model in a limited test is 27.84. This achievement has not classified well, but already above median (27.5), maximum score (55). The research result shows also that an increase of 0.35 reasoning ability students classified as moderate. There are significant differences between prior knowledge and ability of the students by the end of the reasoning ability.

Wider model trial test indicates that guided inquiry learning is more effective in achieving and improvement of reasoning ability student than conventional learning. This indicated by a significant difference between the achievement and improvement reasoning ability student groups of guided inquiry learning with student groups of conventional learning. Achievement and improvement student reasoning ability guided of inquiry learning group is higher than conventional learning group students. The magnitude of the improvement reasoning ability student of guided inquiry learning group is 0.33 including the medium category. Meanwhile, the improvement reasoning ability student of conventional learning group 0.19 is included as low. Although the guided inquiry learning is more effective in achieving reasoning ability student, but the performance is not yet maximum. Posttest scores obtained by students within guided inquiry learning group of 25.6 is still below the median maximum score (27.5), while the post-test scores of reasoning ability students within conventional learning group of 19.63 is still far below the score of reasoning ability student groups within guided inquiry learning.

According to Alberta Learning (2005), inquiry learning is a process in where students are engaged in their learning, formulate questions, investigate widely and then to build understandings, meanings and new knowledge. Thus, inquiry learning is student-centered. Students are actively involved in the investigation, exploring ideas and find solutions. Through activities in this lesson, students will build or construct understanding, meaning and new knowledge. This is consistent with constructivism understanding that all the knowledge we obtain is construction or built by our own.

The research results is consistent with research related about learning with constructivism understanding in improving reasoning ability student, namely research conducted by Windayana (2009), Suhena (2009), and Napitupulu (2011) with the sample subjects are elementary, junior high and high school. These researches use approach / model of learning with understanding constructivism. Approach / learning model is a contextual mathematical learning (Windayana, 2009), the REACT strategy (Suhena, 2009), and problem-based learning (Napitupulu, 2011). The research result by applying the constructivist-based learning shows that any improvement of students' mathematical reasoning abilities by learning constructivism learning better than conventional learning.

Test of *Mann-Whitney* for reasoning ability pretest for Control and Experiment Class Students is discribed in Tabel 4.

Tabel 4. Test of *Mann-Whitney* on representation ability pretest Control and Experiment Class Students

Data Type	Average	*U Mann Whitney*	Z	*sig.* (2-arah)	H_0
Representation ability control pretest	1,47	130,500	-1,797	0,072	Received
Representation ability experiment pretest	1,10				

Mann-Whiyney test results (Table 4) showed that the pretest on representation ability between control and experimental class students did not differ significantly. It can be said that the students' prior learning on reasoning ability is same for both classes.

Tabel 4. T-test result on representation ability posttest and N-*gain* Control and Experiment Class Students

Data Type	*N*	Average	t'	*df*	*Sig*.(2-ways)
Representation ability control posttest Representation ability experiment posttest	10,05 14,65	105,000	-2,454	0,014	Rejected
N-*gain* of Representation ability Control N-*gain* of Representation ability experiment	0,258 0,404	77,000	-3,218	0,001	Rejected

Tabel 4 shows that result on posttest data and N-gain of representation ability student is difference significantly. Posttest and N-gain experimental class is higher than the control class. In other words, guided inquiry learning influences on student achievement and improvement representation ability.

The research result shows that students' achievement of math representation on limited test models is 12.84. This achievement is still relatively low, due to still under median (17.5) of maximum score (35). Nevertheless, guided inquiry learning is effective in improving of reasoning ability student. It demonstrated by the significant difference between beginning knowledge and final abilities of students by the end of math representation. Likewise, improvement of math representation student is 0,303 classified as medium.

Trial result of wider model indicates that extensive guided inquiry learning is more effective in achieving and increasing math representation student than conventional learning. This is indicated by any significant difference between the achievement and improvement math representation between student group of guided inquiry learning with student groups of conventional learning. Achievement and increasing math representation student group of guided inquiry learning group is higher than student group of conventional learning. The magnitude of the increasing in math representation student group of guided inquiry learning group is 0.41 included as medium category.

Meanwhile, the increasing math representation student group of conventional learning is 0.26 included as low category. Although the guided inquiry learning is more effective in achieving math representation student, but these achievements is not maximum. Posttest scores obtained by student group of guided inquiry learning group is 14.65, which still under median of maximum score (17.5), while the post-test scores math representation student group of conventional learning is 10.05, which still under the score of math representation student group of guided inquiry learning.

The research result is consistent with Alhadad research (2010) which concludes that improvement the ability of multiple representations of mathematical learning of students who receives open-ended approach is better than the students who receives the usual learning, reviewed from whole students.

CONCLUSION

The guided inquiry learning is more effective in accomplishment and improvement on reasoning ability and mathemtics representation of student compared with conventional learning. Any significant differentiation on reasoning ability and mathemtics representation between group student of the guided inquiry learning and group student of conventional learning. reasoning ability and mathemtics representation on group student of the guided learning method is higher from the group student of conventional learning. The improvement on reasoning ability group student of the guided inquiry learning is 0.33 is on medium category, while the improvement on math representation group student of conventional learning is 0.19 on the low category. The amount of improvement math representation on group student of the guided inquiry learning is 0.41 on the medium category, and the improvement on math representation group student of the conventional learning is 0.26 on the low category.

The Recommendations are The guided inquiry learning can be used as one alternative to develop and to improve the abilities of reasoning and math representation of junior high school's student. In order to the implementation on the guided inquiry learning carries out according to the objectives, teachers shall pay attention on the following matters; a) to select the appropriate material if applied with the guided inquiry learning; b) to predict the condition faced by student on each stage of the guided inquiry learning; c) to make a teaching material for supporting the learning implementation; d) to make courses for the thinking abilities that will be achieved.

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