

Enhancing Students' Mathematical Reasoning By Algebrator-Assisted Inquiry Method

Yaya S. Kusumah and Vara Nina Yulian
*Study Program of Mathematics Education,
School of Postgraduate Studies, UPI
Jl. Dr. Setiabudhi 229, Bandung 40154
yayaskusumah@yahoo.com*

Abstract

Mathematical reasoning ability is initiated by identifying and analyzing facts and information in a mathematical concept, analyzing relationships between two or more concepts by applying a set of principles/theorems which have been proved, and formulating temporary conclusions until a final conclusion is obtained. Students' mathematical reasoning, however, is one of the problems occurs in teaching and learning process, where many teachers and lecturers encounter with. Their ability in understanding and analyzing mathematical concepts using deductive methods and drawing a conclusion for constructing valid arguments are still poor.

This research was quasi experiment in nature, with pretest-posttest control group design. Inquiry method was implemented with the use of Algebrator for enhancing students' mathematical reasoning. The subject in this research was 80 students from 8 classes in one of junior high schools, in Bandung, West Java, selected by applying purposive sampling technique. The subject of the research was grouped into 2 different groups. The first group was treated under Algebrator-assisted Inquiry method while the second group was given conventional method. The instruments used in this research were mathematical reasoning test and attitude scale. Indicators covered in the test were mathematical connections, relational understanding, deductive reasoning, and critical-mathematical thinking. The measured aspects of attitude consist of interest, motivation, and activities related to mathematics lesson, inquiry method, and mathematical problems in reasoning-based test.

From the data analysis related to mathematical reasoning, it is obvious that the students' weaknesses were in mathematical connections, relational understanding, deductive reasoning, and critical-mathematical thinking. The main factors which made the problems occurred is that there was no sufficient mathematical reasoning integrated into the lecture conducted. Further, there was only a few lectures which integrated logic into the concepts in other subjects intensively. The lack of challenging, divergent, and open ended problems, as well as inadequate exercises given to students, were also the other factors which contributed to the students' difficulty.

Keywords: Mathematical reasoning, Algebrator, Inquiry

1. Introduction

Mathematical reasoning ability, as one of logical thinking skills, plays important roles in inferences, as this ability contains skills in drawing a conclusion based on correct principles/theories and constructing a conclusion. Mathematical reasoning process is initiated by identifying and analyzing facts and information in a mathematical concept, analyzing relationships between two or more concepts by applying a set of principles/theorems which have been proved and formulating temporary conclusions until a final conclusion is obtained [8]. Students' difficulties in mathematical reasoning is one of many problems occur in teaching and learning process, where many teachers or lecturers encounter with. Students' ability in understanding and analyzing mathematical concepts, using deductive methods, and drawing a conclusion in an argument are still poor.

The study resulted by the Trends in International Mathematics and Science Study (TIMSS) in 2003, students have found difficulty in dealing with some problems containing mathematical reasoning ability. Indonesian students in 2003 was in the rank 36 out of 49 participating countries. There were only 44% international students who could solve mathematical reasoning problems, whereas there were 31% of Indonesian students could solve these problems. Compared to Indonesian students, most of students in other Asean countries did much better, as they could reach score higher than 50%. In TIMSS 2007, Indonesian students could answer the question, although the total number of students in this matter only reached 17%, compared to more than 59% Singaporean students who did well in this aspect. In the latest survey conducted by TIMSS in 2011, there was improvement resulted in terms of the achievement gained by Indonesian students, although it is still lower than those gained by students in Syria, Marocco, Singapore, Malaysia, Korea, Finland, and Taiwan [10].

Based on the result of PISA survey, in 2003 Indonesia was in the 38th rank out of 40 countries. In 2006, Indonesia was in the 50th rank out of 59 participating countries. In 2009, Indonesia reached the 61st rank out of 65. Although, it is believed that language is one of the factors which might affect the students' performance in handling the test, the result of this survey shows that there are some efforts that teachers should do for enhancing students' mathematical thinking abilities.

There are some factors related to the poor performances of the students. In [13] it is indicated that students are not well trained in dealing with problems given in TIMSS and PISA as most of the test questions consist of contextual problems and required high mathematical skills. In [1] it is confirmed that students have some difficulties in solving problems which require inferences. However, [7] argues that the decline of students' performances in mathematics was due to the process of teaching and learning which was only focused to procedural routine problems. Most of the teachers strive to explain all the topics covered in the curriculum in a short period of time. In this process students do not understand the basic concepts as prerequisite for the new concepts they learn and no sufficient application context are introduced.

Inquiry method can be implemented as an alternative effort in enhancing students' mathematical understanding and reasoning. Inquiry is the process of investigating and examining a situation in a search for information and truth. This means that students can learn mathematics by exploring the concepts themselves, trying to seek the meaning and application of the concepts [3]. In [5] it is stated that the object or focus of inquiry is either the problem itself or the starting point of the investigation [3]. Based on this statement, it can be interesting and challenging if during the process of investigation information technology is also used to strengthen and deepen the process of investigation so that much more concepts can be understood for further meaningful learning.

To create meaningful learning, the use of information technology can be integrated into inquiry. Computer software can be utilized in the process of inquiry to guide students in dealing with high-order mathematical thinking skills. These characteristics of computer software facilitate students in their exploration process to

gain conceptual understanding [4]. Among the software that can be integrated into inquiry method is Algebrator, a software with interesting features that can visualize geometrical concepts easily and effectively.

The advantages of Algebrator are (a) it can be used for solving mathematical problems in all levels; (b) it can be used for solving mathematical problems by traditional method as well as modern method; (c) it provides descriptive solution step by step in problem solving; (d) it can visualize mathematical problems in graphics mode.

By applying Algebrator, students can (1) observe the result of their problem solving step by step; (b) repeat the activity of the same problem solving at any time; (c) observe the graphics of the problems which is found difficult when it is conducted manually; and (d) enhance students motivation in doing mathematical exercises.

To overcome the above-mentioned weaknesses, a research has been carried out by implementing Algebrator-assisted inquiry method as this method gives students opportunities to identify problems, collect required information, investigate and analyze the result of investigation and exploration to be applied in a new situation. By involving students in inquiry method of learning process, they will be able to construct their own knowledge and put it in their long-term memory permanently.

2. Research Methods

This research was quasi experiment in nature, with pretest-posttest control group design. Inquiry method was implemented with the use of Algebrator for enhancing students' mathematical reasoning. The subject in this research was 80 students from 8 classes in one of junior high schools, in Bandung, West Java, selected by applying purposive sampling technique. The subject of the research was grouped into 2 different

groups. The first group was treated under Algebrator-assisted Inquiry method while the second group was given conventional method. In the first group, where students worked under Algebrator-assisted inquiry method, the following steps were conducted: (a) The students were given mathematical problems; (b) The students were asked to construct conjectures; (c) The students carried out investigation by applying Algebrator and collected data; (d) The students tested the conjecture and formulated a conclusion; (e) The teacher conducted reinforcement on the concepts which have been learned by the students.

The instruments used in this research were mathematical reasoning test and attitude scale. Indicators which covered in the test are: deductive reasoning, where students have to demonstrate their skills in understanding and analyzing given proofs and drawing a conclusion in an argument; inductive reasoning, where students have to show their competency in constructing generalization, describing their analyses on a given model, fact, or pattern in mathematical context, and constructing a conjecture based on a given problem. The students have to show their skills in critical-mathematical thinking by constructing temporary conclusions until they come to a final conclusion. In this research, attitude aspects to be measured consist of interest,

motivation, activities related to mathematics lesson, inquiry method, and mathematical problems in reasoning-based test.

3. Results and Discussions

Below is the result obtained in this research about students' mathematical reasoning ability. In the following table it is clear that the average of mathematical reasoning score is 5.65 (in scale 1-10) with the standard deviation 1.81; while the control group has the average of 5.68 with standard deviation 2.02.

Table 1. Student's Mathematical Reasoning Abilities under Algebrator-Assisted Inquiry Method and Conventional Method

Test Result	Experiment Group				Control Group			
	Min	Max	Ave	SD	Min	Max	Ave	SD
Pretest	2.00	10.00	5.65	1.81	2.00	10.00	5.68	2.02
Posttest	6.00	19.00	14.25	3.44	5.00	19.00	11.93	3.54
N-gain	0.22	0.92	0.61	0.21	0.12	0.91	0.46	0.29

Note: Ideal Maximal Score = 20.00.

Both pretest results are relatively equal, showing relatively small difference (not higher than 0.03). This result indicates that initially the competency of the two groups was relatively equal. The distribution of the data is relatively equal. This can be observed from the table, where the standard deviation of both pretest is relatively equal

(the difference does not exceed 0.21). The students from experiment group reached mathematical reasoning score of 14.25 after inquiry method was implemented, whereas the students from conventional group reached 11.93 (with the ideal maximal score 20.00). This difference is significantly high, which means that Algebrator-assisted Inquiry method contributes mathematical reasoning enhancement to the students. This is in line with the result of previous experiments conducted by [6], [9], [11], [12], and [14], which indicated that inquiry method (without the use of Algebrator Software) could enhance students' mathematical reasoning ability.

The data of normalized gain shows that the students' enhancement in mathematical reasoning ability under Algebrator-assisted inquiry method is 0.61 (middle level), compared to conventional group which reached 0.46 (middle level). Although, both gains are in the same level, the first enhancement, however, shows better result. The middle level of normalized gain which the students have shows that their competence in mathematical reasoning still needs further enhancement. The main factor which contributes to these weaknesses is that there was no sufficient mathematical reasoning integrated into the lectures conducted in other subjects. Most of mathematical concepts in other subjects were delivered without deep analysis in logic, so the students do not get used to proving and analysis in drawing a conclusion. The lack of challenging, divergent, and open ended problems, as well as inadequate

exercises given to students, are also the other factors which contribute to the students' difficulty in dealing with mathematical problems.

In terms of students' affective skills, it is obvious that the students who worked under Algebrator-assisted Inquiry method showed positive attitude toward mathematics lesson, inquiry method, as well as problems in reasoning-based test. The students who had been treated under Algebrator-assisted inquiry method showed adequate interest, motivation, activity and understanding related to the importance of mathematical competency, compared to students in conventional method group. After short period of time, the students' enhancement of attitude is positive, although their improvement were not so high. The students' attitude, apparently, will improve slightly after long period of time, if the students are given this treatment for a long period of time. It seems that this enhancement will not occur instantly after several weeks, no matter how intensive the treatment was.

4. Conclusions

Based on the result of the research, it can be concluded that: (1) the students' enhancement in mathematical reasoning ability who worked under Algebrator-assisted Inquiry method is higher than that of students who worked under conventional method; and (2) the students who worked under Algebrator-assisted Inquiry method showed positive attitude toward mathematics lesson, inquiry method, as well as mathematical problems in reasoning-based test.

The students who had been treated under Algebrator-assisted inquiry method showed positive enhancement of interest, motivation, activity and understanding related to the importance of mathematical competency, compared to the students who were given conventional method. Long time period of treatment is expected to gain high enhancement in students' attitude toward the above-mentioned aspects of attitude.

References

- [1] Amelia, S. (2012). *Pengaruh Accelerated Learning Cycle terhadap Kemampuan Pemecahan Masalah dan Koneksi Matematis Siswa Sekolah Menengah Pertama (Studi Kuasi-Eksperimen pada salah satu SMP Negeri di Pekanbaru)*. Bandung: UPI (unpublished thesis).
- [2] Baig, S., & Halai, A. (2006). Learning Mathematical Rules with Reasoning. *Eurasia Journal of Mathematics, Science and Technology Education*. 2, (2), 15-39.
- [3] Bell, F. H. (1978). *Teaching and Learning Mathematics In Secondary Schools*. Pittsburgh: Wm.C Brown Company Publishers.
- [4] Conway, P. & Sloane, F. (2005). *International Trends in Post-Primary Mathematics Education*. Research Report Commissioned by the National Council for Curriculum and Assessment.
- [5] Ernest, P. (1991). *The Philosophy of Mathematics Education*. New York: The Palmer Press.
- [6] Hutabarat, D. (2009). *Studi Perbandingan Kemampuan Penalaran dan Representasi Matematis pada Kelompok Siswa yang Belajar Inkuiri dan Biasa*. Bandung: UPI (unpublished).

-
- [7] IMSTEP-JICA. (1999). *Permasalahan dalam Matematika SD, SMP, dan SMU di Kota Bandung*. Bandung: FPMIPA IKIP Bandung.
- [8] Kusumah, Y.S. (2008). *Konsep, Pengembangan, dan Implementasi Computer-based Learning dalam Peningkatan Kemampuan High-order Mathematical Thinking*. Oral Presentation in the Inauguration of Professorship in Universitas Pendidikan Indonesia, 23 October 2008. Bandung: UPI Press.
- [9] Lindawati, S. (2010). *Pembelajaran Matematika dengan Pendekatan Inkuiri Terbimbing untuk Meningkatkan Kemampuan Pemahaman dan Komunikasi Matematis Siswa Sekolah Menengah Pertama*. Bandung: UPI (unpublished thesis).
- [10] Mullis, et al. (2007). TIMSS (2007). *International Mathematics Report*. Boston: TIMSS & PIRLS International Study Center.
- [11] Offirstson, T. (2012). *Pembelajaran Geometri dengan Metode Inkuiri Berbantuan Software Cinderella untuk Meningkatkan Kemampuan Penalaran dan Pemecahan Masalah Matematis*. Bandung: UPI (unpublished thesis).
- [12] Subandriyo. (2010). *Metode Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitatif, dan R & D*. Bandung: Alfabeta.
- [13] Whardani, S. & Rumiati. (2011). *Instrumen Penilaian Hasil Belajar Matematika SMP: Belajar dari PISA dan TIMSS*. Yogyakarta: P4TK Matematika.
- [14] Yuniarti. (2007). *Meningkatkan Kemampuan Penalaran dan Komunikasi Siswa SMP melalui Pembelajaran dengan Pendekatan Inkuiri*. Bandung: UPI (unpublished thesis).