

Algebraic Problem Solving: Teacher's Practices Towards Teaching and Learning

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Abstract: Algebraic Problem Solving (APS) is a topic of concern in the teaching and learning of Mathematics. This study aimed to identify teacher's practices on teaching and learning algebraic problem solving in secondary school in Malaysia. Teaching and learning are effective in helping students understanding the concepts of a topic more clearly. A total of eighteen Mathematics teacher were interviewed to obtain information pertaining to the teaching of APS. Based on the result obtained, teacher felt that teaching APS in school is important and at the heart of teaching and learning of Mathematics. Teacher also thought that the concept in Algebra should be taught clearly and well understood by students in order for the teaching APS is running smoothly. Most of the teachers were founded practicing using Polya Model while teaching APS. Essentially, teacher teaching involves four steps as stated in Polya Model when solving problem. However, there are new strategies that they had explored based on their teaching experience and collaboration with other Mathematics teachers in school. This study provides an indication that the teaching practices exhibited by the teachers is very important and can help students reinforce learning APS and this indirectly can improve students higher order thinking skills.

Key words: Algebra, algebraic problem solving, strategy in teaching and learning of algebraic problem solving, thinking skills, indication

INTRODUCTION

To achieve the aspiration of Malaysian education plan 2013-2025, Malaysian education system have to provide greater performance improvement based on other national education benchmarks following the international standards (Ministry of Education, 2013). These improvements include the standards for Mathematics and focus on 21st century skills such as problem solving and reasoning skills as well as technology development. Integrated Curriculum of Secondary School (KBSM) or Standard Curriculum of Secondary School (KSSM) certainly emphasizes the skills mentioned above. Since KBSM implemented, teachers are urged to use the Polya (1973) Model for problem solving. This model emphasizes 4 key steps to solve a Mathematics problem which are first understanding the problem, second, obtain a solving plan, third, implement the solving plan and lastly reviewing the solutions. However, until now a lot of research on problem solving and scientific reasoning shows that student performance is still not that impressive (TIMSS, 2011; OECD, 2010; Zainal, 2011). Therefore, the improvement on performance should be implemented to ensure the education system remained

high performance in developing the virtue and efficiency needed by students to succeed and thrive in an increasingly challenging global world.

In 21st century, problem solving and reasoning skills become the focus for a variety of positive aspects to be developed in students. However, problem solving is a very complex process. Goldin (1992) explains, "the problem solving involves a highly complex aggregate of internal psychological processes which may include verbal and syntactic processing; representation; the use of a variety of complex heuristics; conceptual understanding; a variety of affective responses; metacognitive processes; belief systems about Mathematics". There are problem solving model presented by Mathematics education researchers such as Polya (1973) Model, Schoenfeld (1985) Model and Krulik (1996).

Polya Model is premised from the western that has been recommended for used by teachers and students in the teaching and learning of Mathematics problem solving. However, there is still no significant impact in secondary education in Malaysia as evidence from the research that was performed before. The analysis of the report Trends in International Mathematics and Science

Study (TIMSS, 2011), showing the performance of Malaysian students in Mathematics education declined significantly between 1999 and 2011.

Specifically, three dimension shows Malaysian student achievement unsatisfactory are knowledge (35% questions), applied (40% of the questions) and reasoning (25% of the questions). Average student performance also shows 2-10% of students achieve high benchmarks which at this level, students can interpreting the information, draw conclusions and make generalizations and also able to solve complex problems. This provides an indicator that our students understand the basic concept but just in general and are unable to apply the knowledge besides showing an amount of Mathematics anxiety (Puteh, 2013a). Thus, this research is undertaken to identify the teacher's practices on teaching and learning algebraic problem solving for secondary school students in Malaysia and teachers perception on it.

Problem solving: Problem solving is a very important aspect and is a key objective in the learning of Mathematics. According to Gagne (1985) problem solving is a form of learning at the highest level. As said by McCormick (1997) Mathematical problem solving is a form of higher order thinking in procedural knowledge to determine how the strategies implemented. Higher order thinking consists of critical thinking skills, reasoning skills and decision making. When solving the Mathematical problem, thinking skills, reasoning and decision making were involved and this indirectly form the higher order thinking of students.

KBSM Mathematics syllabus outlines the goals of high school Mathematics curriculum which is to develop Mathematical thinking and competent students to apply Mathematical knowledge effectively and responsibly. Therefore, improvements in the education system must be implemented to achieve these goals. The issue of student crises in Mathematics education not only put pressure on education in Malaysia but also a global problem (NCTM, 2000). United States is placing high hopes on the teaching and learning of Mathematics so they said Mathematics is like a door to more productive future. Thus, in principles and standards for school Mathematics offers students the opportunity to learn and understand the importance of the concepts and procedures of Mathematics (NCTM, 2000).

Algebra: Algebra is one of the branches of Mathematics that uses letters and other signs or symbols to represent numbers and quantities. Algebra was first taught in form

two (Ministry of Education, 1998) but when they realized that the algebra topic is critical and should be considered, therefore the first algebraic concepts taught in form one (Ministry of Education, 2002). Algebra is considered as a "gatekeeper" that is require in most areas of education and employment (Rittle-Johnson and Star, 2007). Many students have difficulty in appreciating the algebra topics. In the topic of algebra, Mathematical word problems involved and a lot of problem solving process used in solving Mathematics problem.

In explaining the techniques of solving Mathematical problems, students tend to solve Mathematical problems using techniques memorizing the procedures and Mathematical operations based on the figures and terms as a keywords (Dollah, 1999; Pardi, 1998). In addition, students perform Mathematical solution without the proper understanding of the overall meaning of a problem (Hegarty *et al.*, 1995). Memorizing techniques and operational procedures can't be denied as the right solutions for routine Mathematical problems. However, students will be confronted with problems when they forget the operating procedure for solving the problem. Conceptual understanding of the topic should be studied and understood by students to enable them to solve Mathematical problems. Students tend to have a certain degree of anxiety whenever they are confronted with solving Mathematical problems and this needed to be overcome and dealt with Puteh and Ibrahim (2010b). Moreover, in solving Mathematics problem, students should not be bound by a common technique solution presented by the teacher only. Other suitable techniques should be encouraged for cognitive development, experience and learning environment by students.

Algebraic problem solving: Global problems in Mathematics education can be seen in the TIMSS report. In first year participating in TIMSS, Malaysia ranked 20th with an average score of 519 in Math. In 2003, the average Mathematics score dropped to 508 while for 2007, the average Mathematics scores declined further to 474. Analysis of TIMSS (2011) shows the performance of Malaysian students in Mathematics education declined significantly between 1999 and 2011. Based on TIMSS report, score that below the average score of 475 is in the category of students who are only able to use basic Mathematical knowledge and not yet able to use Mathematical knowledge in different situations and difficulty. This gives an indication that our students understand the basic concept but just in general not the application of knowledge (Ministry of Education, 2013).

The TIMSS (2007) revealed that the algebra has a lower average score (454) field number (491) and geometry (477). Therefore, research in field of algebra and in area of problem solving are appropriate as an early step to ensure the students improve their understanding and learning in that topic and also how and what strategies the teacher used in delivering the information to their students. Thus, this study submitted to identify the teacher practices of teaching Algebraic Problem Solving (APS) and their perception on it.

Objectives and research questions: This study presents a study which to identify the teacher’s practices in teaching and learning Mathematical problem solving for secondary school students in Malaysia. This study specifically focused on the teaching algebraic problem solving. Generally, the objective of this study was to explore the practices of the Malaysian secondary school Mathematics teachers in teaching of APS. In particular, the research question is:

- What are the perception of teachers on teaching of APS?
- What are the teacher practice of teaching APS?

MATERIALS AND METHODS

This study was conducted at secondary school in Batang Padang district in Perak, Malaysia. The participants in this study are eighteen teachers who thought Mathematics form four and form five. Interview method was used to gather the information. All the participants were interviewed and asked to give their perceptions and views regarding teaching of APS and also their teaching practices of APS. All the teachers (participants) had <10 years of teaching experience. Basically, the participant’s background was in Mathematics education and computational field.

Data analysis: Based on the interviews conducted, the findings of the research questions were obtained. The first research question what are the perceptions of teachers on teaching algebraic problem solving? The findings showed that there are ten perception of teachers towards teaching of algebraic problem solving. The perceptions are showed in Table 1.

Referring to the Table 1, it appears that most of the teachers felt that teaching algebraic problem solving is less attractive and is a difficult topic. However, they agreed that teaching of algebraic problem solving encourage students to think at higher level. Besides,

Table 1: Perceptions of teachers towards teaching of algebraic problem solving

Respondents	Perception									
	a	b	c	d	e	f	g	h	i	j
1	-	-	-	-	-	-	✓	✓	✓	-
2	-	-	-	-	-	-	-	✓	✓	-
3	-	-	-	-	✓	✓	-	-	-	-
4	-	-	-	-	-	-	-	✓	-	✓
5	-	-	-	-	-	-	✓	-	-	-
6	-	-	-	✓	-	-	-	-	-	-
7	-	✓	-	-	-	-	-	-	-	✓
8	-	-	✓	-	-	-	-	-	-	-
9	-	-	✓	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	✓	-	-	-	-
12	-	-	-	-	✓	-	-	✓	-	-
13	✓	-	-	-	-	-	-	-	-	-
14	-	✓	-	-	-	✓	-	-	-	-
15	-	-	✓	-	✓	-	-	-	-	-
16	-	-	-	-	✓	✓	-	-	-	-
17	-	✓	-	-	-	-	-	-	-	-
18	-	-	-	✓	-	-	-	-	-	-

“a”: Follow Polya Model; “b”: Less interest and difficult; “c”: Useful in everyday life; “d”: Abstract thought/topic; “e”: Inducing high order thinking of students; “f”: Variety of teaching methods of problem solving and attract students; “g”: Students are encourage to solve the problem and do a lot of exercise; “h”: Important basic concepts; “i”: Step by step teaching and “j”: Don’t know how to apply the concepts of algebra

there is a perception among the teachers that they think teaching algebraic problem solving attract students if there is variety of teaching methods teach by teacher. In teacher opinion, basic concepts that involves teaching of algebraic problem solving is important and teachers are responsible to deliver it clearly.

Teachers noted that teaching algebraic problem solving is useful in everyday life. Individual habits of everyday life such as buy things, involved a lot of algebraic concepts. Next, there are teachers who state that teaching algebraic problem solving is an abstract thought. Students find it difficult to imagine the used of unknown that involved letters in Mathematical operations. Therefore, teachers felt that teaching algebraic problem solving should be taught step by step to ensure that students are able to understand it clearly. In addition, students are encourage to solve the problem solving questions and do a lot of exercise. From the findings that stated the students don’t know how to properly apply the algebra concepts. From teacher point of view, the teaching of algebraic problem solving is best served using Polya Model which involves a 4 step solution.

Moreover, the second research question what are the teacher practices of teaching algebraic problem solving? Based on the findings obtained, it showed that there are seven practice of teaching algebraic problem solving by teachers involved in this study. According to the result, teaching by emphasize the understanding of concepts and teaching by following the Polya Model are mostly

Table 2: Distributions of the teacher’s practices of teaching algebraic problem solving

Respondents	Practices						
	a	b	c	d	e	f	g
1	✓	-	-	-	-	-	-
2	-	✓	-	-	-	-	-
3	-	-	-	✓	-	-	-
4	-	-	✓	-	-	-	-
5	✓	✓	-	-	-	-	-
6	✓	-	-	-	-	✓	-
7	✓	-	-	-	-	-	-
8	-	-	-	-	-	✓	-
9	-	✓	-	-	-	✓	-
10	-	-	-	✓	-	-	-
11	-	-	✓	✓	-	-	-
12	✓	-	✓	-	-	-	-
13	-	-	✓	-	-	-	-
14	✓	-	✓	-	-	-	-
15	-	-	-	-	✓	-	-
16	-	-	-	-	-	-	✓
17	-	✓	-	-	-	-	-
18	-	-	✓	-	-	-	-

“a”: Understanding concepts; “b”: Explaining and giving examples; “c”: Used Polya Model; “d”: Heuristic Model; “e”: Thinking maps (I-think); “f”: Using easy term and concrete model and “g”: Teach according to students level

used by teacher in teaching. In addition, the teacher’s practices by explaining clearly using appropriate example also become one of the teaching practices carried out. Further, the used of term that easily to understand by students and also using concrete model as example during teaching and learning session is able to provide a clear understanding of the topic. There are some of teacher’s practice teaching based on Heuristic Model and using the thinking maps (I-think). There are also teachers who teach the students according to their level. Different approaches and teaching practices are used according to the level of student whether they are in group of good, moderate or poor students. The distributions of the findings for the teacher’s practices of teaching algebraic problem solving are shown in Table 2.

The purposes of this study are to identify teacher’s practices of algebraic problem solving and their perceptions on teaching algebraic problem solving. Based on the interviews conducted, the findings show that most of the teachers emphasize the understanding of concepts in their teaching practices. Each topic in Mathematics subject have different and its own concepts. Students need to understand the concept of each topic first in order for them to solve the problem solving questions. This finding is in line with previous study by Yahaya and Savarimuthu (2008) which stated that a proper understanding of a concept, especially in Mathematics are able to improve and enhance the quality of Malaysian education and produce a creative and innovative thinking generation. Students who does not able to master the Mathematical concepts and skills will facing a problem in

understanding Mathematics and they potential to assume that Mathematics is difficult (Abu, 1991). Thus, the key to success in Mathematics is through the understanding of concepts.

Moreover, the results stated that teaching by applying Polya Model is used by teacher in their teaching practices. Polya Model involves 4 steps which is understand the problem, planning the strategy, implementing the strategy and review the strategy. Most teacher applied this practices because Polya Model emphasizing the systematic teaching. Students are easier to understand and follow the lessons step by step. Teaching the algebraic problem solving is strengthened by giving a clear explanation as well as appropriate examples. In this way, students can clearly apply the Mathematical concept, effectively. The used of concrete examples helps student to work positively towards Mathematics (Hay and Morris, 1991).

However, in teacher point of view, teaching algebraic problem solving is able to develop higher order thinking skill of students. This in line with the Malaysian Education Plan 2013-2025 (Ministry of Education, 2013) which hope students are able to compete globally. Thus the education that leads to higher order thinking will indirectly be able to produce students who can compete at international level.

The findings also stated that the variety of practice teaching methods of algebraic problem solving able to attract more students to focus during the teaching and learning session. Principles and Standards of School Mathematics (NCTM, 2000) stressed the need for students to practice a wide range of strategies in order to benefit students on the problem solving ability. Problem solving ability is important for students to foster their skills like reasoning skill, problem solving skill and critical thinking skill. These all skills that are important to develop student’s cognitive skill. Solving problems in different ways can develop learner’s mental fluency and flexibility and also encourage solvers to apply their divergent reasoning than fixed by a single Mathematical idea (Leikin, 2009; Star and Newton, 2009; Silver, 1997).

CONCLUSION

Research related to the teaching practices of algebraic problem solving was conducted to identify the practices that most teacher used during the teaching and learning session of algebraic problem solving. Results showed that teacher mostly applying the Polya Model strategy and as well as by emphasizing the understanding of Mathematics concepts. Correspondingly, the teachers expressed their perception on teaching algebraic problem

solving which they felt that teaching algebraic problem solving able to nurture students to think in higher levels. Thus, this indicate that teacher's practices and perceptions are important in encouraging them to put more effort and to improve their teaching in helping students strengthen their learning of algebraic problem solving.

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REFERENCES

- Abu, M.S., 1991. Psychology of Development and Education. Longman Malaysia Sdn. Bhd., Petaling Jaya, Malaysia.
- Dollah, M.U., 1999. Mathematical problem solving: A case study of form two students. M.Ed Thesis, School of Educational Studies, Universiti Sains Malaysia, Penang, Malaysia.
- Gagne, R.M., 1985. The Conditions of Learning and Theory of Instruction. 4th Edn., Holt, Rinehart and Winston, California, USA., ISBN:9784833702287, Pages: 361.
- Goldin, G.A., 1992. Meta-analysis of problem solving studies: A critical response. *J. Res. Math. Educ.*, 23: 274-283.
- Hay, D.A. and D.J. Morris, 1991. Industrial Economics and Organization Theory and Evidence. 2nd Edn., Oxford University Press, New York, USA., ISBN:9780198772231, Pages: 686.
- Hegarty, M., R.E. Mayer and C.A. Monk, 1995. Comprehension of arithmetic word problems: A comparison of successful and unsuccessful problem solvers. *J. Educ. Psychol.*, 87: 18-32.
- Krulik, S., 1996. The New Sourcebook for Teaching Reasoning and Problem Solving in Junior and Senior High School. Allyn & Bacon, Boston, Massachusetts, USA., ISBN:9780205165209, Pages: 337.
- Leikin, R., 2009. Bridging Research and Theory in Mathematics Education with Research and Theory in Creativity and Giftedness. In: Creativity in Mathematics and the Education of Gifted Students, Leikin, R., A. Berman and B. Koichu, (Eds.). Sense Publisher, Rotterdam, Netherlands, pp: 383-409.
- McCormick, R., 1997. Conceptual and Procedural Knowledge. *Intl. J. Technol. Des. Educ.*, 7: 141-159.
- Ministry of Education, 1998. Secondary school curricula: Mathematics. Dewan Bahasa dan Pustaka, Kuala Lumpur, Malaysia.
- Ministry of Education, 2002. Secondary school curricula: Mathematics. Dewan Bahasa dan Pustaka, Kuala Lumpur, Malaysia.
- Ministry of Education, 2013. Malaysian education development plan 2013-2025 (Preschool education until the middle of last). Ministry of Education, Putrajaya, Malaysia.
- NCTM., 2000. Principles and Standards for School Mathematics. 3rd Edn., National Council of Teachers of Mathematics, Reston, VA., ISBN-13: 9780873534802, Pages: 402.
- OECD., 2010. PISA 2009 results: Executive. Organization for Economic Cooperation and Development, Paris, France.
- Pardi, H., 1998. The pattern of third year student problem solves the problem of telling stories in math: A case study. B.Ed Thesis, Department of Mathematics, University of Malaya, Kuala Lumpur, Malaysia.
- Polya, G., 1973. How to Solve it. 2nd Edn., Princeton University Press, Princeton Municipality, New Jersey, ISBN 0-691-08097-6.
- Puteh, M. and M. Ibrahim, 2010. The usage of self-regulated learning strategies among form four students in the Mathematical problem-solving context: A case study. *Procedia Social Behav. Sci.*, 8: 446-452.
- Puteh, M., 2013. Mathematics Anxiety the Need to Overcome it. Sultan Idris Education University, Tanjung Malim, Perak, Malaysia, Pages: 114.
- Rittle-Johnson, B. and J.R. Star, 2007. Does comparing solution methods facilitate conceptual and procedural knowledge? An experimental study on learning to solve equations. *J. Educ. Psychol.*, 99: 561-574.
- Schoenfeld, H., 1985. Mathematical Problem Solving. 2nd Edn., Academic Press, San Diego, California, ISBN:9780126288704, Pages: 409.
- Silver, E.A., 1997. Fostering creativity through instruction rich in Mathematical problem solving and problem posing. *ZDM.*, 29: 75-80.
- Star, J.R. and K.J. Newton, 2009. The nature and development of experts' strategy flexibility for solving equations. *ZDM.*, 41: 557-567.

- TIMSS, 2011. International mathematics report: Findings from IEA-S repeat of the third international mathematics and science study at the eight grade. International Study Centre, Trends in International Mathematics and Science Study, Boston, Massachusetts.
- TIMSS., 2007. International mathematics report: Findings from IEA-S repeat of the third international mathematics and science study at the eight grade. Lynch School of Education, International Study Centre, Trends in International Mathematics and Science Study, Boston, Massachusetts.
- Yahaya, A. and E. Savarimuthu, 2008. The importance of understanding the concepts in mathematics: Problems in science and mathematics education. M.Ed Thesis, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia.
- Zainal, Z., 2011. Metacognition in the process of Mathematical problem solving is not routinely among form four students a case study. M.Ed Thesis, Department of Mathematics, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, Malaysia.