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Teachers's practices in teaching and learning algebraic problem solving

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Abstract

Algebraic problem solving is one of the important areas in learning mathematics. However, the result shows that student's performance in algebra mainly in solving problem is not satisfying. This study had two folds aim that are capturing teacher's view on the teaching and learning algebraic problem solving and also to grasp the idea whether the teacher have implicitly implemented problem posing strategy in a classroom. Thus, the objectives of this study are 1) to gain teacher practices in teaching and learning algebraic problem solving, 2) to find out the difficulties faced by teachers while teaching Form Two students to solve algebraic problem solving, and 3) to find out whether the teachers have implicitly imposed problem posing strategy in a classroom. Participants in the study were 8 experienced teachers who were been teaching mathematics especially mathematics Form Two syllabus and have teaching experience for more than five years. Data were gathered through qualitative technique that is using semi structured interview. Results from the study showed that teachers are still using teachers' centered approach in teaching and learning algebraic problem solving, the difficulty faced by the teachers in teaching algebraic problem solving is students lack of mathematics skills, and teachers rarely used problem posing strategy in a classroom. This study provides an overview that teacher should implement new strategy in teaching problem solving algebra in order to increase student's performance. One of the promising strategies is known as problem posing strategy.

Keywords: Algebraic problem solving, problem posing strategy.

INTRODUCTION

Algebra is one of the important areas in learning mathematics. Although the application of algebra knowledge in real life does not as obvious as in the knowledge of arithmetic, it does limit ones' opportunity to excel in many areas of life such as in business, psychology, chemistry and many more areas [1]. Algebra involves a lot of formulas in calculating solutions to find unknown values for various types of problems and hence it is considered difficult subject. The difficulties to understand the concept of algebra as well as apply the knowledge to solve real life situation are worldwide as studies done by previous researchers [2, 3, 4, 5] reveals that students from different parts of the world face the same problems dealing with algebra.

Algebraic problem solving

Mathematical problem solving is one of the important aspects emphasized in 21st century mathematics pedagogy. According to the National Council of Teachers of Mathematics [6 & 7], mastery of mathematical

problem solving skills will help students to solve problems in daily life. In 2017, Malaysian Ministry of Education (MOE) has revised the mathematics curriculum which was resulted from the reports on the performance of Malaysian students in TIMSS and PISA programmes. The new curriculum known as the Kurikulum Standard Sekolah Menengah (KSSM) was made to support the national development by emphasized on the higher order thinking skills and problem solving [8]. To support this curriculum reform, teaching practices must also change by emphasizing the students-centered approach. This is because, student-centered approach is rooted in constructivism which support several learning approaches including problem posing strategies [9].

In teaching and learning algebra problem -solving sessions, teachers use a four step Polya model to solve problems. The Polya model is recommended in the mathematics curriculum in Malaysia to help students solve algebra problems in a structured manner. However, the TIMMS and PISA reports show that students have not yet mastered problem -solving skills well. The TIMSS reported that Malaysian students' ability to apply knowledge and solve real life problem is still at stake. It can be seen that, the declining trend in the algebra performance among Malaysian students cannot be compromised. In 2003, the average mathematics score was 508 and further declined to 474, 440, 465 and 461 in 2007, 2011, 2015 and 2019 (Mullies et al., 2012, [10]. The scores below 500 reveals that students are not able to apply the knowledge in different situations. Further, [11] also test on problem solving in mathematics. The results indicate that Malaysian students scored thirty percent or below in all domains of the assessed processes of problem solving. This is related to the lack of exposure to problem solving in schools for Malaysian students. Students are exposed to most of the routine math problems in school. The [11] showed that students were able to answer well for objective questions while less encouraging for questions involving problem solving. Further, it is reported that only about 1% were among the top performers who are able to solve the most complex problems at level 5 and 6, meanwhile the rest are concentrated at level 2 and some at level 3 [11]. This fact illustrates how mathematics is taught and tested in many schools in Malaysia.

Problem posing strategies

Problem posing strategy requires students to construct their own problems based on the given examples or even from their own ideas [12]. However, teacher still need to facilitate students in order for them to gain confidence and at the same time give students the opportunity to discover mathematics in an exploratory way [13]. Problem posing strategy require students to analyze existing data, relate the previous knowledge and the new knowledge as well as think critically [14, 15]. This process requires a high level of thinking and ultimately helps students to understand a problem in depth [14]. Through the process undergone in generating problems, students 'understanding of mathematical concepts should increase, they will have more opportunities to delve into these concepts, and as a result, their problem-solving skills can be improved.

Habila Elisha Zuya, (2017) conducted a systematic review of the literature to identify the advantages derived from the implementation of problem posing strategy. The findings show that this strategy benefits students' learning outcomes in three learning domains namely cognitive domain, affective and psychomotor. Further, study conducted by [16] found that problem posing strategy encourage students to be active, creative and self-reliant. In contrast, a study by Christidamayani & Kristanto, (2020) found that problem generation strategies increase students' motivation in all aspects namely interest, enthusiasm, diligence, identity, collaboration and self-control of students to learn. However, this strategy has no significant impact on learning attainment. This indicates that there are other factors that prevent students from achieving good results through this strategy. [17] stated that the main obstacle in implementing this problem posing strategy is due to students lack of experience in generating problems.

Hence, teachers play an important role in preparing themselves with deep mathematical knowledge, as well as carefully arranging learning plans so that the use of problem posing strategies in the classroom has an optimal positive impact on students' achievements in algebra. A study by [18] found that learning by re-producing questions based on examples provided more understanding to students than learning through solving examples of questions and evaluating questions. Therefore, teachers should identify the context of the students' learning as well as the ability of students to generate problems so that the problem posing strategies implemented in the classroom have an impact on students' achievements.

Accordingly, attempts should be made in terms of varying the teaching methods to deal with the topic of algebra so that students would be able to master the subject proficiently [19]. Therefore, this study will analyzed teachers' practices, the difficulties they encountered during the teaching and learning process of algebra as well as their perception on problem posing strategy in order to make improvement in teaching skills as well as to help improve of students' understanding and thinking skills in algebra problem solving.

OBJECTIVES AND RESEARCH QUESTIONS

An understanding of how an experienced Mathematics teacher deliver their lesson in a classroom is crucial to many aspects of teacher education such as it provides relevant information to the types of teaching strategy been used and what can be done to improve it. It also helps to understand the difficulties faced by both teacher and students in the process learning algebra. Therefore, this study had been carried out in order to identify the current teacher's practices in the teaching and learning algebraic problem solving after the new reform mathematics curriculum had been implemented in 2017.

The new mathematics curriculum KSSM is intended to inculcate the higher order thinking skills as well as nurtured students' skills in problem solving [7]. The Ministry of Education, Malaysia has provided guidance upon strategies that can be used to deliver the materials so that students will become a good problem solver as well as able to think critically and creatively [7]. However, the TIMSS and PISA reports indicate that students' performance in algebra is still at par. Therefore, the objectives of this study are 1) to gain teachers' practices in teaching and learning algebraic problem solving, 2) to find out the difficulties faced by teachers while teaching Form Two students to solve algebraic problem solving, and 3) to find out whether the teachers have implicitly imposed problem posing strategy in a classroom. In particular, the research questions are:

- What are the teachers practices in teaching and learning algebraic problem solving?
- What are the difficulties faced by the teachers while teaching Form Two students to solve algebraic problem solving?
- Did the teachers have implicitly imposed problem posing strategy in a classroom?

METHODOLOGY

This study is a qualitative study and uses a semi -structured interview on 8 secondary school mathematics teachers, Ministry of Education Malaysia (MOE) from different schools. This method was used by Aliza (2015) to obtain needs analysis data to produce a play -based approach module. The sample selection technique is done purposefully by selecting respondents from homogeneous groups but able to provide diverse information. All participants were purposely selected based on three criteria: 1) all participants had been teaching mathematics KSSM Form Two syllabus, 2) all participants had teaching experience for more than five years, and 3) all participants had experienced in constructing items for school mathematics test. Since the participants were directly dealing with the process of teaching and learning algebra in class, they were considered as qualified informants. According to [20], those who have working experience for more than five years can be considered as an expert in the field.

Among the participants in the study, 2 were male and 6 were female teachers. 3 of them were at the age between 30 – 39 years old, 4 of them were at the age between 40 – 49 years old and 1 were at the age of 50 years old and above. In terms of teaching experienced, 1 had 5 – 9 years, 4 had 10 – 14 years, 2 had 15 – 19 years and 1 had 20 years experienced and above. The demographic information of the participants is provided below.

Table 1. Descriptive characteristics of the participants.

Gender	f	Age	f	Years of teaching experienced	f
Male	2	Less than 30 yrs old	0	Less than 5 yrs	0
Female	6	30 – 39 yrs old	3	5 – 9 yrs	1
		40 – 49 yrs old	4	10 – 14 yrs	4
		50 yrs old and above	1	15 – 19 yrs	2
				20 yrs and above	1
TOTAL	8		8		8

Procedures

A semi-structured interview guide was developed based on the research objectives focusing on examining the teaching strategies and the difficulties students encountered during the learning process. All questions and answers were in Bahasa Melayu and were also recorded for prospective content analysis. The interview sessions were pre-scheduled and conducted as planned during respondents' free time and it is conducted via *google meet*. The interviews were semi-structured and asked the participants to describe: a) teaching strategies been used to solved algebraic problem solving (e.g., Can you explain the process of teaching algebraic problem solving to Form Two students? Why did you choose the method to explain the process of algebraic problem solving?), b) situations or instances when teaching the process of algebraic problem solving to Form Two students (e.g., Can you describe the students' behavior or acceptance when they learn the process of algebraic problem solving? What are the difficulties the students encountered during the process of learning algebraic problem solving) and c) knowledge or experience using problem posing strategy (e.g., During the teaching and learning process of algebraic problem solving, have you posed your own questions similar to the example given or new questions which relate to the topic been taught? Have you ever asked or encouraged the students to posed their own questions regarding the topic been taught? Did the students try to pose new questions during the process of learning problem solving algebra? Based on your experienced in preparing exam questions, can you explain the process of constructing the items? Do you think that by posing questions, it would help you to understand the topic better? Why is it so? Please explain.'

RESULTS AND DISCUSSION

There were finally 3 themes and 9 subthemes extracted from the qualitative content analysis of the interviews, which were presented in this paper along with sample extracts of the actual interview content. The 3 themes included: teaching strategies in algebraic problem solving, students' difficulties in learning algebraic problem solving and teacher's knowledge and practices about problem posing strategy. Knowledge of these themes can shed light on a new teaching strategy intervention to enhance students' skills in mathematics particularly problem solving skills.

The first research question 'What are the teachers practices in teaching and learning algebraic problem solving?' can be answered under the first theme that is 'Teaching strategies in algebraic problem solving'. The findings showed that there are 12 perceptions of teachers regarding the strategies been used in teaching algebraic problem solving. However, the 12 perceptions could be divided into three subthemes that are 'students' centered learning', 'teacher's centered learning' and 'explanation of easier concept to difficult concept'. Table 2 shows the teachers' perceptions on teaching and learning algebraic problem solving.

Table 2. Theme 1 - Teaching strategies in problem solving algebra.

	A1	A2	A3	A4	A5	A6	A7	A8
Subthemes:								
1. 'students' centered learning'								
- Group activities	√	√		√	√		√	√
- Students solve problem in the whiteboard		√	√		√			
- Problem based learning				√				
- 'Gallery Walk'	√							
2. 'teachers' centered learning'								
- chalk and talk	√	√	√	√		√		√
- using textbook	√	√	√	√	√	√	√	√
- explanation of examples			√		√			
- drill exercises		√	√			√	√	√
- general explanation of the topics	√		√	√	√	√	√	√
- explain using the Polya Model		√	√	√		√	√	√
3. 'explanation of easier concept to difficult concept'								
- teach the basics first								
- explain through examples in the textbook	√	√ √	√ √	√	√	√ √	√	√ √

Based on Table 2, it appears that teachers' centered learning is the popular method in teaching the algebraic problem solving. Majority of the respondents used the 'chalk and talk' method, give general explanation of the topics and also using the textbook to deliver the algebra content. Further, teachers always emphasized on the basic concepts of algebra and provide explanations of solving algebraic problems through examples in the textbook. This is due to the fact that students faced difficulties to understand the questions and also to use the right formula to solve the problems. Therefore, from teachers' perspectives, drill exercises is the right ways to inculcate understanding of the algebraic topic.

Algebraic problem solving questions involved the use of situation in daily lives. Students find it difficult to relate the algebra concepts with their daily lived activities. This is due to the fact that algebra concept is abstract and students faced difficulties to imagine the used of unknown that involved letters in mathematical operations [21]. Majority of the respondents used the Polya Model to teach students on how to solve the algebra problems. Polya Model consists of four main steps that are understand the problem, planning the strategy, implementing the strategy and review process. The respondents stated that by using the Polya Model and group activities, students learnt how to solve the algebraic problem solving questions systematically. When the researcher goes on asking probing question such as 'Why did you choose the method to explain the process of algebraic problem solving?', they said that it was due to the time constraint and the class environment. Most students are Further, the respondents said that the use of Polya Model is been emphasized in the textbook as well as in the Malaysian School Standard Curriculum that provided by the MOE.

The second research question is 'What are the difficulties faced by the teachers while teaching Form Two students to solve algebraic problem solving?'. Based on the findings, there are 8 perceptions of teachers which highlights the students' difficulties in learning algebraic problem solving. However, the 8 perceptions could be divided into three subthemes that are 'students' mathematics skills', 'students' attitude towards algebra' and the 'abstract nature of algebra'. Table 3 shows the teachers' perceptions on the difficulties of teaching Form Two students to solve algebraic problem solving.

Table 3. Theme 2 - The difficulty faced by the teachers in teaching algebraic problem solving is students' students lack of mathematics skills.

	A1	A2	A3	A4	A5	A6	A7	A8
Subthemes:								
1. 'students' mathematics skills'								
- Lack of skills in mathematics operation, factorization and expansion of algebra	√	√		√	√	√	√	
- Confuse on the positive and negative symbol in algebra topic	√	√	√	√			√	
- Problem to solve the equation involved unknown		√		√			√	√
2. 'students' attitude towards algebra'								
- forgot the formulas	√	√		√	√	√	√	√
- forgot the ways to solve the algebraic problems	√	√	√	√	√		√	√
- careless doing the mathematics operations		√	√	√	√		√	√
3. 'abstract nature of algebra'								
- difficult to understand the equal sign	√	√	√		√	√	√	√
- cannot rearrange the unknown and the numbers.		√	√	√		√		√

The analysis based on Table 3 shows that, the problems faced by teachers in the process of teaching and learning algebraic problem solving is mainly due to the students' factor that are the students' mathematics skill and attitude towards algebra. Majority respondents stated that students made mistakes in changing the equations involved the sign of the unknown. Students also faced difficulties to understand the equal sign as well as rearrange the unknown and the numbers. This technical operation requires student to do more exercises on the basic concept of algebra and hence majority respondents stated they regularly do explanation of examples in the textbook and follow up by drill exercises practices to help students master the algebra concepts.

Moreover, respondents claim that their students always forgot the formulas, careless in doing the mathematics operations and also do not know to solve the algebraic problems. This result indicate that students need another strategy that could help them to understand the abstract concept of algebra better. Further, knowing multiple strategies to learn topic in mathematics could enhance students mathematical thinking as well as improves their problem solving skills [22, 23].

The third research question is 'Did the teachers have implicitly imposed problem posing strategy in a classroom?'. This type of question been raised by the researcher in order to know whether the teachers have practiced the problem posing strategy in a classroom or not without they realized it. Based on the findings, there are 15 perceptions of teachers which indicate that majority of the respondents do not implement problem posing strategy in a classroom. The 15 perceptions are divided into three subthemes that are 'teacher's knowledge on problem posing strategy', 'teacher's practices on problem posing strategy' and 'teachers' opinion on problem posing strategy'. Table 4 shows the teachers' knowledge and practices about problem posing strategy.

Table 4. Theme 3 - Teacher's knowledge and practices about problem posing strategy.

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**
1. 'teacher's knowledge on problem posing strategy'								
- I know problem posing strategy.	√	√						
- I never heard about problem posing strategy.			√	√	√	√	√	√
2. 'teacher's practices on problem posing strategy'								
- I never asked students to posed questions.	√	√	√		√	√		√
- I seldom asked students to posed questions.				√	√		√	
- I did pose my own questions on the topic been taught.	√	√	√		√		√	√
- I did pose similar questions to the examples given.		√		√		√		
- Students did not pose their own questions regarding the topic been taught.	√		√		√	√	√	√
- Students rarely pose their own questions regarding the topic been taught.		√		√				
3. 'teachers' opinion on problem posing strategy' based on their experienced constructing the examinations' items								
- Can enhance mathematics skills in the topic learned.	√	√	√	√	√	√	√	√
- Able to increase higher order thinking skills.	√	√		√	√		√	√
- Able to understand the topic clearly.	√	√	√		√	√		√
- The strategies should be done in group	√		√	√	√	√		√
- The strategies should be done in individually		√		√			√	
- Time constraint	√	√	√		√	√		√
- Need more exercises	√		√		√	√		√

The analysis in Table 4 shows that majority respondents do not know about problem posing strategy. Teachers do not asked students to posed questions due to the time constraint. As respondent A1 stated, 'to posed questions, students will take time to discuss and create questions' meanwhile A5 noted that 'to solve problems ... sometimes we do not have enough time to finish the discussion in class'. However, most respondents said that they do posed their own questions in supporting the given examples to instill students' understanding about the topic. Further, students do not posed questions during the learning sessions. They prefer to listen and ask about the answers. A2 stated 'higher achiever students might be able to posed questions but the low achiever students may not be able to because of their limited knowledge in basic concepts of algebra'. Majority respondents agreed that, based on their experienced in constructing examination items, posing problems may help to increase students' higher order thinking skills, however the lesson plan should be well prepared in order to battle the time as well as provide suitable activities that could engage students with the problem posing strategy.

In order to grasp the idea whether the problem posing strategy benefited students in terms of increasing their knowledge and skills in mathematics, the researcher asked the respondents opinions about their experienced when constructing questions for exam school purposes. The questions such as 'Based on your experienced in preparing exam questions, can you explain the process of constructing the items? Do you think that by posing questions, it would help you to understand the topic better? Why is it so? Please explain.' Majority of the respondents stated that, the process of constructing items or proposed questions requires one to think deeply and creatively. It also helps to understand better about the topic learned because one need to know the topic as a whole and make connections in order to construct questions that is non routine and can be solved. Based on the responses, in can be hypothesize that the problem posing strategy have the potential to help increase students' higher order thinking skills and problem solving skills. This findings was in line with the studies by [14, 16, 24]. Higher order thinking skills and problem solving skills are two important skills that students need to master in learning mathematics. These skills also had been emphasized in the new mathematics curriculum KSSM [7] because of its importance in developing students capabilities in mathematics problem solving.

CONCLUSION

Research related to teaching practices on algebraic problem solving is crucial because it contributes towards enhancing the teaching and learning strategy that benefited students. Based on analysis results in this preliminary study, teachers are practicing the Polya Model in order to solved algebraic problem solving questions. Further, teacher preferred to use conventional teaching method such as using the 'chalk and talk' method to deliver the algebra content. This approach focusing on the teachers' role as a transmitter of knowledge [25]. Research done by [19] found out that this method is still effective in explaining the conceptual of a topic such as the main concept of algebra. However, combining the conventional method of teaching with other strategies such as problem posing might enhanced students understanding in algebraic problem solving [19]. This is because, when students need to posed their own problems, it will make them engaged with the learning process as well as thinking creatively [15] and hence it could built students' understanding on algebra concept. Correspondingly, the respondents agreed, based on their experienced in constructing examinations items, that the problem posing strategy had promising impact on students thinking skills as well as problem solving skills. Therefore, further studies need to be implemented in order to get the empirical evidence on the benefits of the problem posing strategy on students by taking into account all the points discussed previously.

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