

# Malaysian and American Preservice Teachers' Ability and Perspective on Mathematical Problem-Posing

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**Abstract** Problem-posing has received considerable attention among the mathematics education community. In the present study, researchers explored preservice teachers in two countries in terms of their ability and perspectives on mathematical problem-posing. Twenty-four preservice teachers in a secondary school program in Malaysia and 26 preservice teachers in the middle school program in the United States participated in this study. The preservice teachers posed at least three mathematical block pattern problems and these were categorized according to structures, mathematical concepts, languages, and relevance elements. The results showed the American preservice teachers demonstrated better performance on the structure, mathematical concepts, and compatibility elements. The inferential analysis showed significant differences in problem-posing skills between these two groups of preservice teachers on structure ( $U = 149.5$ ,  $p = .006$ ) and relevance ( $U = 156.50$ ,  $p = .008$ ) of the mathematical problems. Both groups had similar perspectives related to posing mathematical problems. Implications for classroom instruction were also discussed.

**Keywords** Problem Generation, Prospective Teachers, High-order Thinking Skills, Mathematics Instruction

## 1. Introduction

Since the 1990s, promoting problem-posing as an important aspect of teaching and learning of mathematics has been increasingly growing, especially in the United States of America. Many studies have shown problem-posing can enhance skills, attitude, confidence, concept understanding, and students' mathematical thinking (Cai & Hwang, 2019; Rosli et al., 2020; Singer, Ellerton, & Cai, 2015). In addition, Ponte and Henriques (2013) found when engaging in problem-posing activities

students would strengthen students' basic skills, boost motivation, encourage responsibility and nurture critical thinking in mathematics. Other researchers claim problem-posing activities are useful for teachers to assess students' cognitive processes and to improve classroom instruction (Cai & Hwang, 2019; Rosli et al., 2020). When an individual poses a problem, thinking and reasoning processes are utilized together with a problem-solving strategy to generate new problems (Ayllón, Gómez, & Claver, 2016).

Considerable research on mathematical problem-posing has been done at various educational levels around the world. However, many of the related studies tend to focus on school students' abilities in problem-posing (Chapman, 2012). For example, recent research done by Ozdemir and Sahal (2019) found sixth-graders' abilities to pose problems progressed, and the students became aware of their mistakes with integers after a series of problem-posing activities. Similarly, Kopparla et al. (2018) focused on 45 students in grades 2-5, who participated in a 3-month problem-posing and problem-posing intervention. Results showed teaching problem-posing significantly influenced the students' ability to generate problems in different contexts.

Unfortunately, studies on mathematical problem-posing among teachers explore diverse contexts of problem-posing, but the numbers are very limited. For instance, Malaspina, Torres, and Rubio (2019) stimulated in-service teachers' didactic analysis competence through problem-posing activities. The study revealed some teachers had the mathematical capability when posing problems, but most of the teachers had insufficient ability to reflect on their problem-posing practices. Similarly, Land, Tyminski, and Drake (2019) found teachers' responsive problem-posing on children's mathematical thinking was developing as teachers' noticing skills grew with the aid of the *Responding Rubric*. Unfortunately, problem-posing is also less focused on during teacher

training education classes. In one recent study, with only  $n = 19$ , prospective secondary teachers, Crespo and Harper (2019) examined posing collaborative mathematics problems highlighting the role of teacher educators in supporting adequate knowledge and providing experiences for preservice teachers. These preservice teachers were asked to pose high-quality problem tasks that incorporated interdependence, accountability and multiple competencies. Thus, we strongly believe in-service and pre-service teachers need appropriate frameworks and focused sessions to improve their abilities and skills with problem-posing.

To fill this gap in the literature, the present study explored Malaysian and American preservice teachers' abilities and perspectives on mathematical problem-posing. The knowledge of this comparative study enables teacher educators to gain a depth of understanding with a differing problem-posing performance of preservice teachers from the two different countries.

## 2. Methodology

The exploratory research focused on two groups of preservice teachers from Malaysia and the United States of America (U.S). The selected participants from the U.S. were 26 preservice teachers who were working toward a Middle-Grade Certificate in Education at a public university in Texas. While in Malaysia, 24 preservice teachers were involved in their final year of secondary school education courses and awarded a Bachelor in Education majoring in Mathematics and minoring in Chemistry/Physics or Biology. The block pattern task by Cai and Lester (2005) was adopted and was administered during one class session in each of the countries. Preservice teachers were required to pose at least three mathematics problems related to the given task within 20 minutes. The preservice teachers were also asked to express their perceptions of the problem-posing activities they were involved in during the class sessions. Neither group of students had any prior experiences in posing mathematical problems.

The problem posed was evaluated (1-4 scores) according to the problem-posing rubric from Rosli et al. (2015). The assessment of the problem posed used four criteria: structure, mathematical concepts, language, and relevance. The maximum score for each problem posed was 16, with a total score of 48 points for any participant. The coding of the problems was conducted by two researchers (inter-rater agreement) with a percentage of 78% for similarity; discussions were carried out to achieve 100% agreement. Quantitative data were analyzed using SPSS version 22 for answering the research questions. The qualitative data were analyzed the problem-posing experiences used QDA Miner software through the unitizing of the narrative responses

(citation needed).

## 3. Results and Discussion

The posed problems were evaluated in terms of structure, mathematical concepts, language, and relevance that followed the rubric criteria of Rosli et al. (2015). The analysis was conducted with 50 preservice teachers who successfully posed mathematics problems associated with the block pattern presented to them. In the first stage, the problems generated were categorized according to the mathematical problem, related pattern, solution steps, and creativity. The findings showed that the selected preservice teachers in the United States posed 93.6% of problems related to mathematics or matching a given pattern while in Malaysia, the preservice teachers were able to pose only 87.5%. Three pre-service teachers (2 Malaysian, 1 American) posed unclear or incomplete mathematics problems. However, preservice teachers from Malaysia posed more two-step solution problems (54.1%) as compared to their counterparts in the United States (28.8%).

Generally, three of the select American preservice teachers earned the highest overall score of 32 points. Every problem posed by these preservice teachers received a satisfactory rating in terms of structure, mathematical concepts, language, and relevance. Examples of the problem posed were:

*How much would it cost a builder to build each of the brick staircases shown above if each brick cost \$1.25?*

*Marcela has completed her new kitchen floor. She decides to do the living room of the dollhouse as well but does not want to be left with extra tiles. What can be done that Marcela is left with no extra tiles? (Hint: Each tile is 3 cm x 1 cm, and the living room is 12 x 5 cm)*

Importantly, many of the problems posed by the American preservice teachers utilized daily life context from their previous experiences to demonstrate problem-solving. They believed the usage of everyday context was relevant to attract students to solve and understand the applications of mathematics. These forms of mathematical problems can help students improve their thinking skills. On the other hand, Malaysian preservice teachers focused only on posing problems in the form of mathematical theoretical concepts. For example:

*The area of a box is 2 cm<sup>2</sup>. The number of boxes increases every step and has its pattern. Find the pattern and calculate the total area of boxes in the 8<sup>th</sup> step.*

*The box is a square with side 1 cm. The number of boxes increases according to the number of steps. The boxes increase by two in the 2<sup>nd</sup> step, three in 3<sup>rd</sup> step, and so on. Find the perimeter of the boxes in the 6<sup>th</sup> step.*

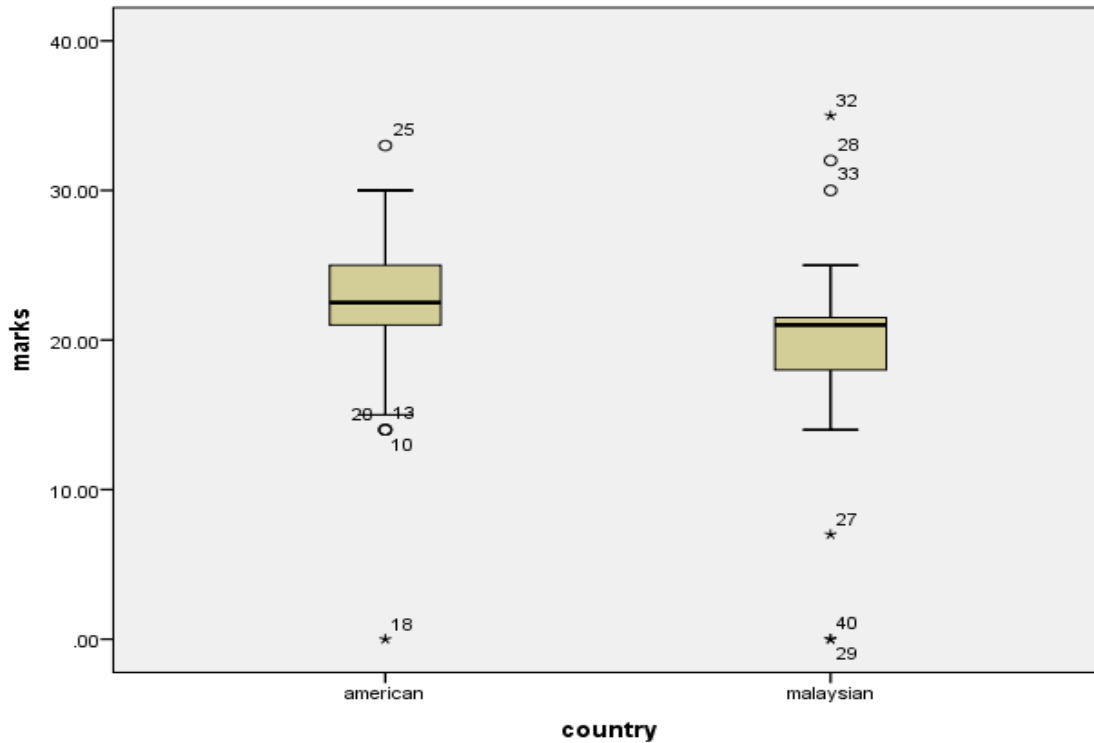


Figure 1. Boxplots of problem-posing scores

The boxplot in Figure 1 illustrates the distribution of total marks on problem-posing task by country. Several outliers and extreme values on the high and low end were observed from the overall patterns of both distributions. The medians are incredibly close (22 scores), thus approximately half the preservice teachers in both groups had scores of over 22. When the outliers and extreme values are excluded, the Malaysian group varied much less than the American group. Further analysis of inferential statistics showed that select American preservice teachers had higher scores for structure, mathematical concepts, and relevant aspects of problem-posing, demonstrating better performance than their counterparts. The Mann-Whitney analysis in Table 1 presents a significant difference ( $\alpha=.05$ ) on the structural ( $U=149.5, p=.006$ ) and relevance ( $U=156.50, p=.008$ ) aspects of problem-posing skills between Malaysia and the U.S. preservice teachers after considering a more valid alpha value based on the Bonferroni adjustment ( $\alpha = 0.05/4 = 0.12$ ). For mathematical concepts and language, preservice teachers from these two countries showed no significant differences. In general, both groups of preservice teachers had similar performance when posing problems. The results showed the majority of them do not gain much experience in generating or reformulating mathematics problems during their teaching preparation program. This finding was consistent with a previous study by Crespo and Harper (2019). Even though problem-posing has been more recently discussed in the mathematics education community, problem-posing activities are not totally integrated as a significant part of teacher education

programs.

Table 1. Problem-posing Element Analysis

		Sum of Ranks	Z Value	Significant Value
Structure	Malaysia	402.50	-2.769	.006
	United States	725.50		
Mathematical Concept	Malaysia	509.00	-.429	.668
	United States	619.00		
Language	Malaysia	570.00	-.920	.357
	United States	558.00		
Relevance	Malaysia	409.00	-2.654	.008
	United States	718.50		

#### 4. Preservice Teachers' Perspectives on Problem-Posing

After the problem-posing activity, the preservice teachers were also asked to provide their perspectives on the aspects and criteria they considered when they generated and reformulated problems. Their statements were coded in the form of word, phrase, sentence, or paragraph unit data (Onwuegbuzie & Weinbaum, 2017). Through this comparative analysis (Onwuegbuzie & Weinbaum, 2017), 13 themes were identified and grouped into four meta-themes: structural, mathematical concepts, language, and relevance. Based on Figure 2, both groups of preservice teachers had very similar perspectives on

problem-posing activity. They believed posing realistic, understandable, and logical problems (39 units of data) was most important. Malaysian preservice teachers stated relevant mathematical concepts (24 units of data), and problems that had a solution (20 units of data) were more important aspects to consider when posing a mathematical problem.

On the other hand, the American preservice teachers noted the difficulty levels (14 units of data) and age level or students' level (12 units of data) were essential aspects. The generation of problems that emphasized higher-order thinking skills was expressed as a significant aspect by the preservice teachers in Malaysia, which was in line with the

mission of the Malaysian Ministry of Education (10 units of data). On the other hand, the U.S. preservice teachers tend to pose problems similar to the ones they had solved and seen previously (10 units of data).

Findings from the qualitative analysis demonstrate both groups of preservice teachers are able to express their views on the critical aspects of problem-posing even though the activities carried out were their first experience. The assessment showed most of the generated problems was less robust in terms of language and mathematical concepts used. In other words, the posed problems included typical daily life contexts.

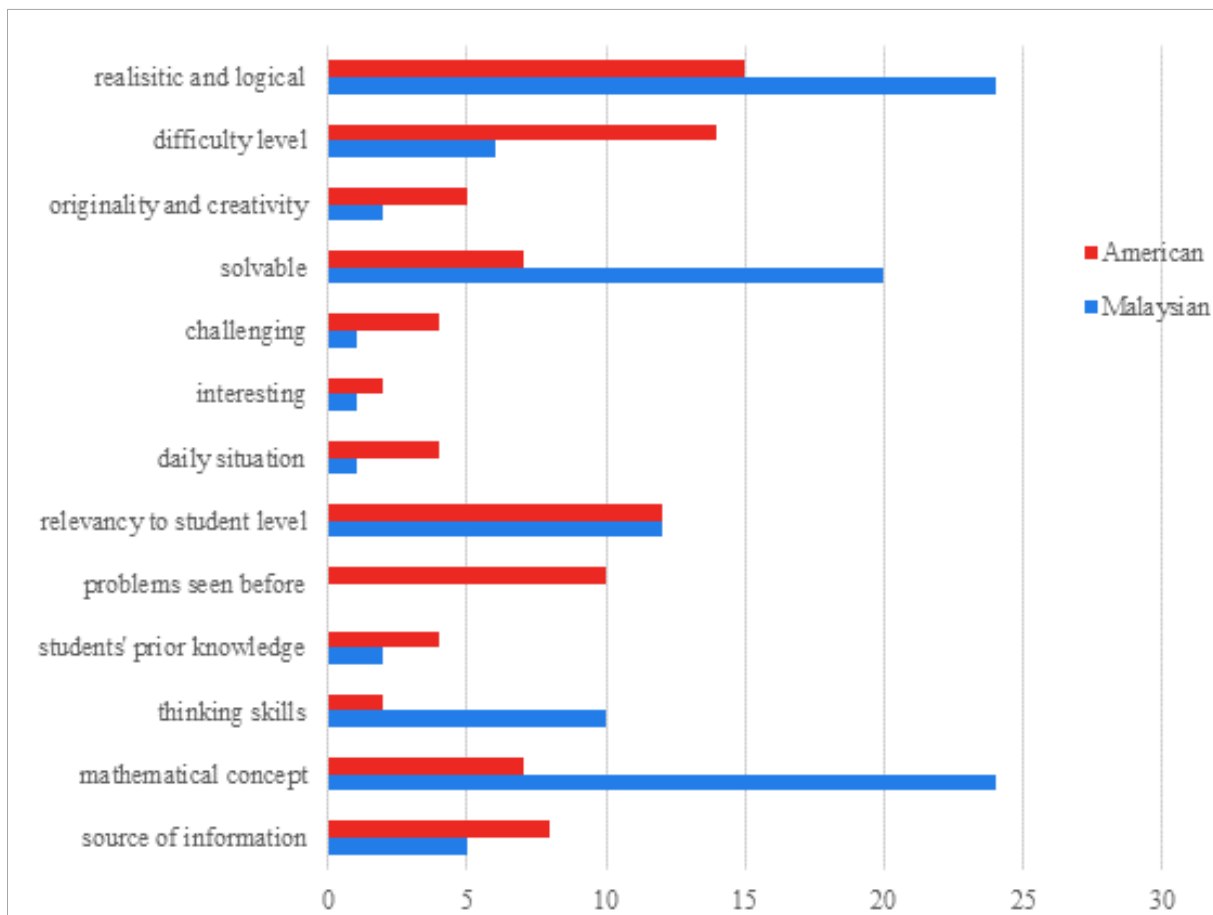


Figure 2. Aspects of problem-posing

## 5. Conclusions

The study results are useful for the mathematics education community in utilizing problem-posing activities during classroom instruction. Along the same line, many past studies also supported mathematical problem-posing as a vital teaching skill to cultivate critical thinking among preservice teachers, teachers, and students. Hence, teachers and educators in teaching institutions are encouraged to integrate problem-posing as a cognitive activity that can enhance higher-order thinking skills if implemented effectively. At the same time, teacher education institutions play an essential role in providing sufficient knowledge and pedagogical skills for helping preservice teachers develop their potential for effective classroom instruction. Further studies should be conducted to examine factors such as content knowledge, attitude, creativity, and language aspects that could affect mathematical problem-posing skills among preservice teachers.

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