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ASKING THE RIGHT QUESTIONS: INSIGHTS FROM A MATHEMATICS TEACHER SUPPORT PROGRAMME

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Abstract: This study investigated mathematics teachers' questioning techniques when teaching problem solving. This is due to evidence that suggested teachers employed many close-ended questions leading students to merely answer what teachers wanted to hear. Hence, 35 primary and secondary mathematics teachers were enrolled as participants in a professional development session on techniques of questioning developed by the Institute of Teacher Education of Malaysia. This session facilitated the participants on how to employ effective questioning techniques when teaching problem solving that focused on four main areas, namely: checking understanding, encouraging conjecturing, making connections and encouraging reflection. The participants were then randomly divided into groups to plan a lesson and deliver it to their peers. Data were collected through observation of lesson delivery to determine if there exist any changes in the way the participants posed questions when teaching problem solving in mathematics. The findings indicated that the participants posed questions in all four areas, with most emphasis on checking understanding and encouraging reflection. The participants also employed a considerable amount of both open-ended and close-ended questions in their delivery.

Keywords: Question, teacher questioning, questioning technique, open-ended, close-ended

INTRODUCTION

Teacher questioning plays a crucial role when conducting mathematics lessons. Previous studies evidently demonstrated that suitable and effective teacher

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questioning has the potential to engage interactive learning and student engagement (Harrold, 2013); foster students to communicate mathematically (Mason, 2002; Mason, Burton, & Stacey, 2010), and to elicit students to reason mathematically (Johnny, Mahani, Mohd Salleh, Noor Azean, & Abdul Halim, 2017).

Classroom observations conducted across Malaysia found that approximately 12% of lessons delivered by teachers were at a high standard, consolidating best practised pedagogies; however, 70% of the lessons observed were centred on recalling facts (Kementerian Pelajaran Malaysia, 2012). Despite having initiated higher order thinking type problems in mathematics classrooms, many teachers still practised questions pertaining to recalling facts (Shanmugam & Ahmad Johari, 2014), and procedural understanding to solve mathematical problems (Mohamad Nizam, Mohd Salleh, Abdul Halim, Noor Azean, & Mahani, 2014).

Johnny et al. (2017) and Wong (2015) also highlighted that mathematics teachers employed many close-ended questions when teaching problem solving in mathematics that appeared to led students to merely answer what teachers wanted to hear. This situation indicated that students were possibly repeating answers based on what they have been taught by their teachers instead of employing effective thinking skills when solving mathematical problems. A preliminary investigation conducted upon randomly selected primary and secondary mathematics teachers too indicated similar findings.

The findings from these literature and investigation suggested that particular teachers needed some assistance to refine their practice of teacher questioning, with focus on becoming more receptive to students' thinking. As the National Key Result Area (NKRA) in the education aspect under the Government Transformation Programme has selected Professional Learning Communities (PLC) as one of its initiatives to ensure the sustainability of quality teachers (Bahagian Pendidikan Guru, 2013); it is possible that the solution to this issue could be executed through teacher professional development sessions. One of the fundamental principles of PLC is to ensure student learning (Bahagian Pendidikan Guru, 2013). Likewise, effective teacher questioning too leads to students learning.

In order to achieve this focus, a suitable strategy was implemented through a session of professional development upon teachers to facilitate them to pose effective questions when teaching problem solving in mathematics. Hence, this study intended to investigate if questions posed by teachers displayed any changes in comparison to their conventional manner of posing questions.

METHODOLOGY

This study was conducted using qualitative approach with case study design. As the participants of this study would eventually undergo a session of professional development tailored specifically for the learning of mathematics in the English language, three state education departments under the southern region of Peninsular Malaysia assigned teachers from schools that conduct mathematics lessons in the English language as participants. They comprised of 35 mathematics teachers of primary and secondary schools from three states of Malaysia: Johor, Melaka and Negeri Sembilan, as described in Table 1.

Table 1. Demography of the participants

School type	State	Number of participants
Secondary	Johor	5
	Melaka	2
	Negeri Sembilan	3
Primary	Johor	6
	Melaka	6
	Negeri Sembilan	3
Tamil Primary	Johor	3
Chinese Primary	Johor	3
	Melaka	3
	Negeri Sembilan	1

Initially, a survey was conducted to identify the types of questions these participants posed when teaching problem solving in mathematics. The outcomes of this survey identified three categories of teacher questions according to their purposes: check understanding; clarify algorithms; and check answers. The questions posed were similar to the findings by Johnny et al. (2017) and Wong (2015), whereby, they consisted of close-ended questions. Among the common examples of questions posed by the participants are enlisted in Table 2.

Table 2. Categories and common examples of questions posed by teachers

Question category	Example
Check understanding	"Do you understand?"
Clarify algorithm	"After this, we…"
	"Then, we need to…"
	"To find …, we must …"
Check answers	"Finally. We get the answer that is …"
	"And the answer is…"
	"Did you get the correct answer?"

Subsequently, they were enrolled into a session of professional development pertaining to techniques of questioning developed by the Institut Pendidikan Guru Malaysia (2018). This session was conducted throughout a three-day support programme organised by the Malaysian Ministry of Education for the southern region of Peninsular Malaysia. The session facilitated the participants on how to use effective questioning techniques comprising of four main areas when working on problem solving in mathematics: checking understanding, encouraging conjecturing, making connections and encouraging reflection. The participants were then randomly divided into groups of five to plan a 30 minutes mathematics lesson of their preferred topic in primary or secondary Mathematics and deliver it via macro teaching among their peers. Figure 1 describes the flow of the whole session.

Day 1

Lecture: Effective questioning techniques

Workshop: Creating question based on particular learning standards

Presentation: Role play and feedback

Day 2

Individual lesson planning: Draft a 30 minutes lesson

Group lesson planning: Select one of group member's lesson plan and prepare resources

Lesson delivery: Macro teaching based on lesson plan

Day 3

Lesson delivery: Macro teaching based on lesson plan

Feedback and evaluation

Figure 1. Overview of the professional development session

Observation was conducted during each groups' lesson delivery via macro teaching. The observation criteria was focused on two areas. Firstly, the employment of the four types of questions during lesson delivery: checking understanding, encouraging conjecturing, making connections and encouraging reflection. Secondly, the responses by the participants who role played as students that resulted from the type of questions posed. The lesson delivery was transcribed into written form. They were also video recorded for the purpose of future references during analysis.

Thematic analysis was used to analyse all data transcribed from the observation. Particular themes related to the types of questions and responses that resulted from these questions were extracted manually. In order to ensure reliability that both researchers rated each theme with the correct type of questions, the thematic coding were compared using a simple percentage of agreement. The inter-rater agreement was valued at 92.6%.

OUTCOMES FROM THE OBSERVATIONS

All seven groups that were observed displayed changes in the way they posed questions during their delivery via macro teaching. The analyses identified that all four areas on effective questioning were executed during their delivery, namely: checking understanding, encouraging conjecturing, making connections and encouraging reflection. This was evident particularly when working on problem solving activities. Table 3 delineates the types of questions employed and some of the examples of questions asked by the participants during the lesson delivery.

The first three questions on checking understanding posed by the participants indicated the use of close-ended questions. Meanwhile, the fourth and fifth questions were evidently open-ended to check understanding. The questions also indicated that there was a substantial change in the way questions were posed to check understanding when compared to the common manner of teacher providing explanation followed by the question "do you understand?".

Pertaining to questions posed by teachers to encourage conjecturing, it was much evident that all participants employed open-ended questions. These questions displayed an extensive variety of responses from the participants who played the role of learners during the macro teaching session. It was particularly evident that this type of questions posed not only encouraged conjecturing as an individual, but also involved whole group participation. In response to the questions above, the participants who played the role of learners appeared to discuss among themselves, debate about their views and appeared to modify their understanding of particular

concepts as they began to accept or reject each other's views. Out of the seven groups that delivered their lesson, only three groups employed a question each that was related to encourage conjecturing; however, the questions were considerably significant in gauging active participation within the participating groups compared to other types of questions.

Table 3. Categories of questions and examples of questions posed by teachers

Question category	Examples of question
Checking understanding	What is the shape of your polygon?
	How many faces are there on your polygon?
	Which do you think is the interior angle in this diagram?
	Can you name any hexagon shapes around you?
	Why do you say that a rectangle has only one axis of symmetry?
Encouraging conjecturing	What would happen to the area of these tiles if I take one tile away?
	Can you find any relationship between the length of chord and the length of arc in this circle?
	Why is circle not a polygon?
Making connection	Can you find any regular polygon that has a different number of axis of symmetry from the number of its sides?
	Why do you say that a rectangle has only one axis of symmetry?
	What is the difference between these notes (money)?
	How do you get a square from a rectangle?
Encouraging reflection	Using this circle, can you draw and name as many parts of the circle you remember?
	Which items in this pamphlet cost less than RM50?
	How do you know?
	How did you get the answer?

Questions posed by the participants related to making connections also indicated the use of only open-ended questions. The reactions observed in response to these questions posed indicated similar outcomes to questions pertaining to encourage conjecturing. Not many questions of this category were employed by the participants; nevertheless, it led to a variety of responses from the participants who played the role of learners. In addition, it was also notable that these questions led most of the participants to look back at their written work; mostly, writing algorithms and sketching. There is a possibility that they were rechecking their written work to ascertain their solution before stating their verbal responses.

The fourth area on effective questioning that was executed during their delivery was encouraging reflection. The questions outlined in Table 3 as employed by the participants suggested two common purposes, namely: to ascertain if learners were able to review what they have learned, and how did they obtain the solution. The purposes appeared similar to the findings in the preliminary investigation prior to undergoing the professional development session. However, the way the questions were posed changed. Instead of filling in words or phrases as shown in Table 2, the questions led learners to elaborate their understanding or solution.

SOLUTION

Based on the findings obtained from the observations, the close-ended questions posed during the macro teaching delivery appeared to check learners' understanding and encourage reflection. On the other hand, open-ended questions were posed in all four areas of the questioning technique: check understanding, encourage conjecturing, make connections and encourage reflection.

FURTHER INSIGHTS

The observation findings described in the previous section indicated that the participants displayed substantial changes in the way they pose questions when teaching problem solving in mathematics. It was evident that the participants employed a considerable amount of both open-ended and close-ended questions in their delivery compared to the extreme use of close-ended questions initially. It cannot be said that the conventional way of posing close-ended questions as found practised among the participants in the preliminary investigation is totally unsuitable. Nevertheless, employment of close-ended questions has its advantage and disadvantage.

Mason (2002) termed this type of questioning as cloze technique, where a teacher pauses during a statement or question and expects students to fill in the missing word or phrase, especially technical terms. Meanwhile, Johnny et al. (2017) pointed out that this type of question posed by teachers was merely to produce correct answers, particularly algorithms, rules or facts. Besides, Mason (2002) and Johnny et al. (2017) stressed that rehearsing or chorusing expected words to fill in the blanks of teachers' verbal questions appeared to lead teachers to do the reasoning instead of encouraging students to think and reason. Mason (2002) also highlighted that carrying out this technique of rehearsing repeatedly would enable students to memorise without using mental imagery; however, there is also

a possibility that they may chorus without understanding what is actually going on. Hence, it may be much effective if cloze technique was used to get students to fill in the reasoning aspect as found among the examples of close-ended questions posed by the participants after the intervention, instead of simply parroting terms, algorithms, rules or facts when completing teachers' statements.

On the other hand, open-ended questions appeared to provide a wider range of responses compared to the close-ended questions when executed. The observation also highlighted that the participants seemed more active in their discussion, debate and even modified their understanding. These observation outcomes indicated that open-ended questions were able to elicit mathematical thinking and reasoning among the participants. These findings were evidently parallel with the findings by Hafizah, Badariah, Aini and Salina (2012) who pointed that open-ended questions stimulated analytical thinking, critical thinking, and thinking out of the box among learners. Besides that, effective use of open-ended questions not only encourage the participation of classroom talk, but also develop skills in both oral and written responses among learners (Department for Education and Skills, 2013).

Although there were not many questions posed by the participants to elicit conjecturing and making connections, the impact from the few questions asked during the macro teaching delivery was much noteworthy. The reaction by the group members in response to the questions posed involved providing ideas, justifying, analysing, and modifying understanding to finally come to a common conclusion; whereby, it was similar to the findings of previous studies (Chin & Liu, 2009; Hunter, 2014).

Based on these findings and insights, it was apparent that the participants required some form of professional development session to assist them to ask effective questions when teaching problem solving in the mathematics classroom. The outcomes of this study clearly showed that the process of unlearning and relearning how to pose questions did not modify the entire approach of teaching problem solving in mathematics. However, the integration of the alternative questioning technique developed by Institut Pendidikan Guru Malaysia (2018) into the conventional way of questioning employed by the participants have somehow transformed them into a different mathematics teachers.

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