ASSESSING MATHEMATICAL THINKING OF PRIMARY SCHOOL STUDENTS

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The recently reviewed primary school mathematics curriculum in Malaysia expects students to be provided with opportunities to develop their mathematical thinking. At the moment, not much is known about the extent of the development of primary school students' mathematical thinking. The traditional paper-and-pencil achievement tests normally given to students are insufficient for assessing the true picture of the students' mathematical thinking. To assess students' mathematical thinking, teachers need to use assessment techniques that will collect evidence about the students' mathematical thinking process. This paper presents the result of an assessment of students' mathematical thinking through an item consisting of open ended tasks. The tasks will involve students checking for possibility of more than one solution to a problem.

Background

As we embark into the new century, there is a call to rethink our basic tenets of education. There is a need to see education not as a process for transmitting knowledge to children, but as a process of opening the children's minds to the world around them. To do this we need to enable children to think for themselves (Schank, 2004).

As a result, improving students' thinking has become one of the major goals of education all over the world. In line with the rest of the world, Malaysia also realized the need to develop and improve students thinking (Malaysian Ministry of Education, 2001). In fact Lipman (2003) believes that we should help children to think well and to think for themselves not for reasons of social utility but because children have the right to receive nothing less.

We expected that through learning subject matter such as mathematics, students will be provided with the opportunities to develop their thinking. Unfortunately, based on the common practice in many traditional classrooms today, students do not have adequate opportunity to develop mathematical thinking while in the mathematics classroom. Mathematics teachers will not be able to fully develop their students' thinking by only teaching students with the skills and knowledge of using mathematical procedures in solving routine problems and exercises.

To develop student's mathematical thinking, the National Council of Teachers of Mathematics (NCTM) has proposed that there should be more emphasis in the process of problem-solving, reasoning and communication in the mathematics classroom (NCTM, 2000). According to Goos (2004), mathematical thinking is an act of sense-making and rests on the processes of specializing, generalizing, conjecturing, and convincing. She also believes that mathematical thinking can be generated and tested by students through participation in equal-status peer partnerships. Therefore to engage students in mathematical thinking, they should be allowed to experience the actual processes through which mathematics develops.

In Malaysia, this emphasis towards development of students' mathematical thinking is fairly new and not much is known about the extent of the development of students' mathematical thinking and what is going on in the classroom that is helping in this development. Therefore, the study was aimed assessing the students' level of mathematical thinking.

Objectives

In many mathematics classrooms today, students learn mathematics as acquiring the mastery of a set of predetermined procedures and skills. Teachers perceived their job as transmitting the content

of mathematics by demonstrating the correct procedure and ensuring students practice the skill of using these procedures (Goos, Galbraith & Renshaw, 2004). When students are able to provide a correct answer to the question posed by teachers, both teachers and students felt satisfied and thought that they have acquired the kind of thinking valued by society. Teachers will continue with the traditional practice of teaching. Regrettably, when teachers limit the students' learning by asking students to blindly follow their examples, students can pretend they know the mathematics that was taught by memorizing and reproducing the correct answer.

Therefore, the traditional paper-and-pencil tests normally given to students are not enough in assessing the true picture of the students' mathematical thinking. According to Cai and Cifarelli (2004, p. 73), " ... studies of mathematical thinking need to focus more on the ways that students conceptualize a problem and develop appropriate solution strategies rather than whether or not they can carry out a formal algorithm to reach a solution."

The problem this study was trying to solve was that the students' level of mathematical thinking had not been authentically assessed. In short, the objective of the study was to assess the mathematical thinking in primary schools in Malaysia especially their ability to make decisions and to justify their decision using open ended tasks.

Methodology

A written test was constructed by the authors to assess the level of mathematical thinking of Primary Year 4 students especially their ability to make decisions and justify their decision. One of the items, which is Item 3 in the paper-and-pencil test required students to make decisions and justify their decision using open-ended tasks. Figure 1 presents Item 3 that were used to gather the data.This item was administered to 516 Primary Year 4 students from 7 schools selected from 4 states in Malaysia, namely Terengganu, Kedah, Johor and Kuala Lumpur.

Item 3

Sally's mother had fried 38 curry puffs for Sally's birthday party. She divided the curry puffs equally to everyone present at the party and found that she had 2 curry puffs left.

(a) How many people were at the party?
(b) Show how you got the answer.
(c) Is that the only possible answer? Why?
(d) If there are other possible answers, how many possible answers can there be?
(e) Explain and show how you are going to find all the possible answers.

Figure 1. Open ended tasks for assessing mathematical thinking

Findings

The students' responses in Item 3 were scored using the scoring guideline as shown in Table 1.

Table 1
Scoring Guidelines for Item 3

Types of response	Score
Omitted	0
Incorrect answer (without explanation)	1
Correct answer (without explanation)	2
Incorrect answer (with reasonable explanation)	3
Correct answer (unreasonable explanation)	4
Correct answer (reasonable explanation)	5

The result of the descriptive analysis of Item 3 showed a mean score of 1.43 and the standard deviation of 1.57. The lowest score obtained for this item was 0 and the highest score obtained was 11. The maximum possible score for this item was 11. Table 2 shows the frequencies and percentages for the type of responses of students for Item 3 of the Mathematical Thinking Test.

Table 2
Frequencies and Percentages of the Responses of Students for Item 3

Types of response	Score	Frequency	Percentage
Item 3 (a)			
Omitted / Incorrect	0	239	46.3
Correct	1	277	53.7
More than one answer	2	0	0
		516	100.0
Item 3 (b)			
Omitted / Incorrect explanation	0	270	52.3
Partial explanation	1	208	40.3
Full explanation	2	38	7.4
		516	100.0
Item 3 (c)			
Omitted / Incorrect	0	440	85.3
Correct answer (without explanation)	1	64	12.4
Correct answer (reasonable explanation)	2	12	2.3
		516	100.0
Item 3 (d)			
Omitted/ Incorrect	0	512	99.2
Correct	1	4	0.8
		516	100.0
Item 3 (e)			
Omitted / Incorrect	0	477	92.4
Incoherent explanation	1	20	3.9
Partial listing of possible answers	2	18	3.5
Full listing of possible answers	3	1	0.2
Explain using logical reasoning	4	0	0
		516	100.0

Table 2 shows that part (a) of Item 3, about half (53.7 %) of the students answered correctly but none of them gave more than one answer. For part (b) of Item 3, 40.3 % of the students gave partial explanation and 7.4 % of the students gave full explanation. For part (c) of Item 3, about 85.3 % either did not answer or give the wrong answer and only 2.3 % of the students were able to give correct answers with reasonable explanation. For part (d) of Item 3, all students except one either did not answer or give the wrong answer. For part (e) of Item 3, about 92.4 % either did not answer or give the wrong answer and only 0.2% of the students were able to give a full listing of all the possible answers.

Discussion and Conclusion

Even though about 46% of the students were able to find a right answer to the question asked in Item 3 (a), the results of analysis of Item 3 (c) indicated that many students (85%) were unable to identify that there might be more than one solution to the task given in Item 3 (a). It seems that students thought that getting a right answer to a question means that, it is the only right answer to the question. The results indicate that many students tend to think that there is only one right answer to any question. They seldom attempt to seek any other solution or answer to a problem.

Even when asked to identify any other possible solution to the problem, they straight away discounted that possibility.

The probable explanation for this phenomenon may lie in the type of questions usually asked in tests or classroom exercises given to students. Students were seldom asked open ended questions which might have more than one possible solution. They were also seldom asked to seek the possibility of other solutions after having solved a problem. Therefore the consequence of any assessment that only asks for the solution of a problem is students who assume that any problem has only one solution.

Therefore, to remedy this situation, teachers should provide students with more open-ended problems in their assessment. Students who are provided with more than one solution should be given positive feedback. This will give a clear signal to all students regarding the importance of checking for the possibility of other solutions to a problem.

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