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Error analysis and the corresponding cognitive activities committed by year five primary students in solving mathematical word problems

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Abstract

The purpose of this study was to identify errors and the corresponding cognitive activities committed by the 374 year five primary school students in solving the mathematical word problems for the 'Fraction' topic. The design of this study used *Newman Error Analysis* method and interviews. The findings showed that 52.91% of the errors made were due to lack of understanding, followed by transformation skills (22.37%), process skills (15.55%), encoding (8.84%) and reading (0.34 Based on these findings, the researchers proposed that teachers should ask students explicitly what problems they have in solving the mathematical word problems, observe students reactions and analyze errors committed by them.

Keywords: Error analysis; cognitive activities; problem-solving; mathematical word problems.

1. Introduction

Matematics is a knowledge that is being applied in other areas which involves problem solving in various contexts. The Ministry of Education Malaysia (MOE) (2003) emphasized the need for every student to be able to explain the mathematical concepts, acquire the mathematical skills and apply them in daily life situations. The mastery of the mathematical concepts and the skills of problem solving will help the students to make less mistakes in trying to solve many problems. According to the National Council for Teachers of Mathematics (NCTM) (1989, 2000), the mastery of the mathematical concepts and problem solving skills are two very important skills to acquire in modern mathematics which is different from those days. Thus, today's mathematics curriculum focuses on the introduction of skill concepts and its application in solving daily life problems (Baroody & Hume 1991; Parmer; Cawley & Miller 1994; Bottge 1999; Woodward & Montague 2000).

When solving a mathematical word problem, cognitive factor also contributes to the effectiveness of solving the problem (Ismail, 2009). Each student will make different mistakes when solving problems (Hollander 1978, Lankford 1974, Radatz, 1979). According to the National Assessment of Educational Progress (NAEP 2000), one of the topics that students usually made mistakes is fraction. This is because of their understanding of the concepts of fraction itself.

This phenomena is also supported by the MOE Malaysia (2004) which stated that students usually made mistakes in solving fraction problems. There are five hierarchical areas put forward by Anne Newman (1977) that can be used to help students identify those mistakes. Those areas are reading, comprehension, transformation, process skills and encoding. Prakitipong &

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Nakamura (2006), on the other hand categorized those mistakes into two different forms such as language problems and the on-going problem solving process. These categorization proposed by them is actually the continuity of what Newman had said. This understanding can help teachers identify the influence of language factor on learning mathematics and its corresponding remedial efforts taken in the teaching and learning process (Clarke 1989).

Some of the questions that can be asked to the students for the purpose of categorizing their mistakes are:

a. Please read this problem for me. If you cannot read it just ignore it.
b. Tell me what does this question wants you to solve.
c. Tell me how you get the answer.
d. Show me how did you solve the given problem
e. Now, write down the answer you had gotten before in the space provided.

Again, to reduce this 'fraction' mistakes, the mastery of concepts and problem solving skills act as the basic requirements for students to acquire. In addition to that, Kieren (1980) suggested that students should learn 'number operations' first before learning fraction, ratio, division, operation and measurement. This is important in terms of the sequence of the mathematical topics to learn.

2. Methods

The purpose of this study was to identify the mistakes and the corresponding cognitive activities committed by the students while solving the fraction word problems. This study combined both quantitative and the qualitative approaches. Data was collected from the document analysis procedures, interviews and checklist. The choice of this approach is suitable with the methods used in the *Newman Error Analysis* by Newman (1977). The quantitative data is analyzed descriptively based on percentage. The cognitive activities were synthesized from the qualitative data. This method was in agreement with Gay, Mills & Airasian (2006), Ginther, Ng & Begle (1976) dan Rotman (1991). Ten fraction word problems were given to the year five primary school students to analyze the mistakes made and the cognitive activities taken when solving them. The problems given were meant to test their understanding of fraction concepts and their applications in daily life. Students were encouraged to show all the tasks in the calculation process. These problems were administered on the year five students in Kuala Terengganu town in one of the states in Malaysia.

3. Findings

Analysis showed that 52.91 % of the mistakes made were due to comprehension. This was followed by transformation skills (22.37%), process skills (15.55%), encoding (8.84%) and reading (0.34%). These results suggested that most students did not understand the word problems which are related to the language problems. On the other hand, the high score of mistakes due to comprehension can also be related to cognitive activities that might caused the mistakes made by the students. Some of the cognitive activities not acquired by the students were understand (read) the word problems (41.22%), identify the information embedded in the word problems (16.35%), explain the information in the word problems (11.53%) and choosing the formula to be used (8.02%). Cognitive activities that were not acquired by the students while applying the transformation skills are to identify which operation to be used (28.65%), to identify the steps of problem solving (14.84%), to identify the strategies to be used (8.85%), and relating the information identified with the information needed (8.34%). Other major cognitive activities not acquired by the students in the process skills were to solve the problems till end (48.21%), implement the operations that had been planned (26.30%), solve the problems based on the information given (8.76%) and used formula to solve problems (3.59%).

Encoding activity means students write the answer in the space provided. The answer written was the final answer attained towards the end of calculating the problems and was based on the cognitive activity of checking back the steps to the answer. Some of the cognitive activities that were related to the incomplete encoding activity were students made mistakes of writing the answers in the spaces provided (16.6%), simplify the answers (16.43%) and recalculate the problems (7.58%). In conclusion, the two cognitive activities of making mistakes of writing the answers in the spaces provided and simplified the answers are the common ones committed by the students.

4. Discussion and Suggestions

Mathematical mistakes made by the students are related to the cognitive activities, metacognitive ability, attitudes and knowledge that they have (Ismail 2009). The difference in the levels of these attributes caused different

mistakes committed and also the different capabilities each students have when solving mathematical problems (Sophian & Crosby 2008; Siegler 2007; Hoard et al. 2008; Geary et al. 2008). Problem solving is a type of a cognitive strategy along with its sub-skills which is planned systematically by an individual to achieve its goal (Cruikshank & Sheffeld 1992; Hamilton & Ghatala 1994; Kontowski 1997; Krulik & Rudnick 1993; Mahmud 2001; Orton 1992; Schwartz & Riedesel 1994; Swenson 1994; Wrekelgram 1974). This type of problem solving will involve some steps, heuristic and specific mental operations (Van Dijk & Kintsch 1983). According to Wrekelgram (1974), problem solving is an effort to overcome obstacles in order to reach a goal using some cognitive and metacognitive skills. When a student try to solve a fraction problem, an obstacle will arise if he or she does not able to identify the needed information in the problem (Kantowski 1977). If the student does not have a strategy or a clear method of solving the problem he or she will face a challenging situation. This situation become more challenging if he or she does not understand the problem, not able to select the correct operation, does not have experiences with similar problem and the problem is not related to his or herself (Krulik & Rudnick 1980).

A lot of steps are involved when a student try to solve a mathematical word problem. It starts with understand the problem first and then figuring out the process needed to solve the problem. In usual case, students will compare the current mathematical problems with the previous problems that they had tackled before. In the process of solving the problem, students have to select which knowledge to use and not to use. Davidson & Sternberg (1998), Polya (1973) and Schoenfeld (1987) pointed out that the knowledge of metacognitive and cognitive skills will help students build a thinking plan which involves strategy, skills and procedures to solve the given problems. This new thinking plan is connected to the students' understanding of the relevant mathematical concepts that will be used. While solving the problems, students will go through two phases such as interpretation of the mathematical language and the calculation process (Jerman 1973; Mayer 1978; Paige & Simon 1966). (Jerman 1973; Mayer 1978; Paige & Simon 1966). The first phase involve interpreting the language in the form of numbers and equations. The usual problems faced by students are they don't understand the language, the sentences and the words they read. The transformation skills used during the mathematical problem solving means plan the strategy (Polya 1957), develop a strategic plan (1978), model the problem in picture forms and abstracts (de Vault 1981), designing the solving method (Beyer 1988), exploring, planning and select certain strategies (Krulik & Rudnick 1996). A student has to understand the problem properly and plan thoroughly in order to do the transformation step. During planning the solving method, students will scrutinize, record and retrieve all the data in the memory needed to understand the problem. In this phase, students will find the relationships between the information and the formulas that will be used. In planning, students will use all of his or her experiences to solve the problems (Beyer 1988). Beyer says the three main skills adopted during planning stage are stating the goal to achieve, determine the operation or strategy that will be used to achieve the goal and identifying the obstacles that might arise in the way of solving the problem (Dirkes 1985). Thus, a careful planning is important to help students achieve his or her goal satisfactorily.

Finally, mathematics teachers need to be concern of the common errors committed by their students and able to relate to which cognitive activities that caused the problems. One of ways to accomplish this is they need to learn how to identify these errors in the classrooms based on certain procedures. This information will allow them to determine the remedial steps to be taken to help the students to learn mathematics more effectively.

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