Cognitive Skills of Mathematical Problem Solving of Grade 6 Children

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ABSTRACT

This study investigated the metacognitive dimensions on the cognitive skills of mathematical problem solving. It involved 275 grade six pupils of District 1, Quezon, Bukidnon during the academic year 2010-2011. This study used the descriptive method of research. The instruments used were the cognitive tasks, prediction and evaluation tasks, and interviews conducted by the researcher. Percentages, means and t–test paired were computed. Findings revealed that the pupils cognitive skills was below average in terms of numerical comprehension, simple linguistic sentences, contextual information, mental visualization, number system knowledge, relevant information, number sense estimation, procedural calculation and average in terms of symbol comprehension. The grade six pupils of District 1, Quezon, Bukidnon had low metacognitive prediction and evaluation dimensions. There was a significant difference on the prediction and evaluation of the grade six pupils on their cognitive skills. Thus, they should be provided with both knowledge of cognitive processes and strategies, and experience or practice in using both cognitive and metacognitive strategies and evaluating the outcomes of their efforts to enhance their cognitive skills and metacognitive dimensions.

Keywords: cognitive skills, evaluation, prediction, metacognitive evaluation, metacognitive prediction.

INTRODUCTION

Problem solving is an important component of mathematics education because of its practical role to the individual and society. “By learning problem solving in Mathematics, students should acquire the ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations that will serve them well outside the mathematics classroom” (NCTM, 2000). Although problem solving is an integral part of all Mathematics, many students struggle with solving problems. Research shows that students’ “ability to solve word problems falls far below their ability to compute because children do not know how to choose the correct operation to apply to the problem” (Burns, as cited in Goldberg, 2003).

Teachers in the Philippines struggle with helping children learn Mathematics. The Philippine Daily Inquirer reported on May 23, 2010 that in the 2003 Trends in International Mathematics and Science Study, the Philippines ranked near the bottom, third from the bottom among 25 countries in the fourth grade and fifth from the bottom among 45 countries in the eighth grade. These speak of the need to identify specific determinants of students’ poor performance in mathematical problem solving. One solution is to measure the specific cognitive skills and metacognitive dimensions of the pupils. Thus, the purpose of this study is to determine how the grade six pupils used metacognition and cognition to make sense of mathematical problems.

ISSN 1839-9053

Specifically, this study aimed to a) describe the level of the cognitive skills in mathematical problem solving among the grade six pupils in terms of numerical comprehension, symbol comprehension, simple linguistic sentences, contextual information, mental visualization, number system knowledge, relevant information, number sense estimation, procedural calculation; b) determine the level of the metacognitive dimensions in terms of prediction, evaluation; and c) compare if there is a significant difference between their prediction and evaluation on the cognitive tasks.

CONCEPTUAL FRAMEWORK

Psychologist Lev Vygotsky proposed that children learn through interactions with their surrounding culture. Vygotsky's theory states that the cognitive development of children and adolescents is enhanced when they work in their Zone of Proximal Development (ZPD for short). To reach the ZPD, children need the help of adults or more competent individuals to support or scaffold them as they are learning new things. Bruner, a psychologist, posited a cognitive theory of learning. He suggests that mathematical structures can be build up in the mind of learners by providing experiences that allow them to develop inactive iconic and symbolic representation of concepts of Mathematics. Flavell (as cited in Hines & Kritsonis, 2008) defined cognition as "one's ability to organize and execute processes in a sequential manner". With problem solving, students translate numerical comprehension (NR), symbol comprehension (S), simple linguistic sentences (L), and contextual information (C) into a mental visualization (V) of the word problem. Next, they organize number system knowledge (K), relevant information (R) and number sense estimation (N) into a procedural calculation (P). The calculations are translated into computing the solution (Desoete, Roeyers, & Buysse, 2001).

The capacity to examine and control one's own thoughts or self–monitoring is known as metacognition. Metacognition is essential for any extended activity, especially problem solving, because the problem solver needs to be aware of the current activity, of the overall goal, the strategies used to attain the goal and the effectiveness of those strategies. Metacognitive processes can operate consciously or unconsciously and they can be accurate or inaccurate. They can also fail to be activated when needed, and can fail to have adaptive or beneficial effect. Metacognition can lead to selection, evaluation, revision or deletion of cognitive tasks, goals, and strategies. They can also help the individual make meaning and discover behavioral implications of metacognitive experiences (Flavell, 1987). Wong (as cited in Livingston, 1997) stated that metacognition has to do with knowledge and awareness of one's cognitive strengths and weaknesses as well as self–regulation, which guides an individual in the coordination of that awareness while engaged in cognitive abilities.

According to Flavell (as cited in Hines & Kritsonis, 2008), metacognition consists of both metacognitive knowledge and metacognitive experiences or regulation. Metacognitive knowledge refers to acquired knowledge about cognitive processes, knowledge that can be used to control cognitive processes. With Mathematics, metacognition measures students' predictions, monitoring, and evaluation of word problems. Prediction impacts students' speed for working on word problems. Evaluation measures the quality of students' reflections on strategies for achieving desired solutions.

METHODOLOGY

The participants of the study were the 275 grade six pupils from the five elementary schools in Quezon 1 district. The schools were classified into big-sized, medium-sized, and small-sized school according to its population. From a group of 275 pupils included in the study, 9 pupils were randomly selected for the oral interview. The researcher, with the help of their mathematics teacher randomly selected 3 pupils in

ISSN 1839-9053

every school classification which gave a total of 9. Three of them performed well in their mathematics class, another three were not so good, and the other three performed low in their mathematics class. The instruments used in collecting the data were the Cognitive Tasks, the Prediction and Evaluation Tasks, and Semi–structured Interview Protocol. The cognitive tasks, and prediction and evaluation tasks were adapted from the EPA 2000 (Desoete, De Clerq, & Roeyers, 2000; Desoete, Roeyers, & Bussye, 2001). However, some revisions were made by the researcher particularly the questions in the cognitive tasks in order to fit to the level of the participants in this study. The questions in the Cognitive Tasks were on whole numbers and its operations. To determine their cognitive levels, this scale was used: very poor 0.00-0.50, poor 0.51-1.50, below average 1.51-2.50, average 2.51-3.50, above average 3.51-4.50, and excellent 4.51-5.00.

The Prediction and Evaluation Tasks is a 5 point rating scale. To determine the levels of the respondents' prediction and evaluation, the same scale in determining the cognitive levels was used. To determine the pupils' level of metacognitive prediction and evaluation dimensions their mean scores in cognitive skills and prediction and evaluation were compared. They have high metacognitive level if their cognitive skills are consistent with the prediction and evaluation; otherwise, they have low metacognitive level. The Semi–Structured Interview Protocol was also adapted from Tan (2009). Though, the researcher revised some of the questions. Information gained from the interview was used for descriptive purposes to support or to refute findings from the other data sources especially in metacognitive dimensions.

The participants of the study were given two hours to answer the questionnaires. First, the pupils were asked to fill in the prediction tasks by reviewing first the cognitive tasks then predicted their success on a 5–point rating scale. Afterwards, they performed the cognitive tasks then, filled in the evaluation tasks to evaluate their performance. The interview was done orally and individually for approximately 10 to 15 minutes right after the pupils finished answering the prediction and evaluation tasks and cognitive tasks.

RESULTS

It was found out that the participants were at below average level on the eight of the nine cognitive skills. Their skills in numerical comprehension, simple linguistic sentences, contextual information, mental visualization, number system knowledge, relevant information, number sense estimation and procedural calculation yielded the mean scores of 2.28, 2.41, 1.81, 1.80, 2.44, 2.09, 1.84 and 1.96, respectively; while their symbol comprehension skill was at the average level with the mean score of 2.52. The total mean score was 2.12 which mean that in general, the participants' level of cognitive skills was below average.

The metacognitive prediction and evaluation dimensions of the participants were low. Their prediction and evaluation mean scores in all the 9 cognitive skills were above average which was inconsistent with their cognitive mean scores which were at below average level in numerical comprehension, simple linguistic sentences, contextual information, mental visualization, number system knowledge, relevant information, number sense estimation, procedural calculation and at the average level in symbol comprehension skill.

There was a significant difference on the prediction and evaluation of the grade six pupils. The prediction mean scores on the nine cognitive skills which were 3.64, 3.82, 3.91, 3.66, 4.01, 3.78, 3.97,

ISSN 1839-9053

3.81, and 3.77, respectively were increased in the evaluation mean scores. These were 3.76, 3.99, 4.04, 3.78, 4.15, 3.90, 4.06, 3.95, and 3.88, respectively. The computed t-values were -4.142, - 5.047, - 3.687, - 4.328, - 2.899, - 3.485, - 3.256, -4.648, and - 3.646, respectively which were all significant at 0.01 level.

DISCUSSION

As stated above, in general, the pupils' level of cognitive skills was below average. This result supports the statement of Mayer and Hegarty (as cited in Marcia, 2007) that pupils need to know how to understand and represent problems in mathematical terms. This implies that the participants in this study lack guidance of a more experienced and competent mathematics teacher. According to Vygotsky's theory, children can do more with the help and guidance of an adult or other person more experienced person than they can do by themselves.

The pupils' inconsistency of prediction and evaluation on their actual cognitive tasks results implies that the metacognitive prediction and evaluation dimensions of the participants were still untapped and underdeveloped. They do not know what they know and do not know. The pupils were only instructing, directing, and questioning their selves. They failed to monitor, evaluate, and regulate their selves. Their prediction and evaluation were only gut feelings. This explained why their cognitive skills were below average in spite of their above average prediction and evaluation. As stressed by Tan (2009), without self-directing or self-instruction, self-questioning that is directed by a self dialogue or self talk, self-monitoring, and self-evaluating, solving the mathematical problems at hand would take a long time and without direction. They may be able to self-instruct or self direct and self-question but self-monitoring, self-evaluating, and self regulating are indeed hard for the poor problem solvers with untapped and underdeveloped metacognitive skills.

The evaluation mean scores on the nine cognitive skills were all greater than the prediction mean scores. This means that the pupils had higher evaluation than their prediction. This implies that the pupils had greater confidence with their answers after reviewing it. Thus, pupils give much importance on evaluating their answers. This supports the statement of Flavell (1979, 1987) that evaluation measures the quality of students' reflections on strategies for achieving desired solutions. The attitude shown by the pupils was good and must be continued by them. However, they must learn to involved metacognition whenever they are predicting and evaluating their cognitive skills to ensure that they will be able to solve the problems correctly.

RECOMMENDATIONS

Elementary mathematics teachers should be advised to improve their teaching skills on numerical comprehension, simple linguistic sentences, contextual information, mental visualization, number system knowledge, relevant information, number sense estimation, and procedural calculation.

Pupils/children must be exposed to more experienced and competent teachers for them to acquire more activities and experiences that would stimulate creative thinking of the pupils to increase their level of cognitive skills. Assessment of the cognitive skills of the teachers must also be conducted to find out the corresponding trainings needed by the teachers and that appropriate teaching materials should be written. Cognitive Strategy Instruction (CSI), an instructional approach which emphasizes the development of thinking skills and processes as a means to enhance learning must also be introduced to the teachers through seminars. Its objective is to enable all students to become more strategic, self-reliant, flexible, and productive in their learning endeavors.

ISSN 1839-9053

Metacognitive dimensions must be taught explicitly as an integral component of problem solving to help pupils understand, learn, develop, and practice the metacognitive processes. The learner should be provided with both knowledge of cognitive processes and strategies, and experience or practice in using both cognitive and metacognitive strategies and evaluating the outcomes of their efforts. Simply providing knowledge without experience or vice versa does not seem to be sufficient for the development of metacognitive control.

Administrators must send teachers to various in-service trainings, workshops and seminars on how to train pupils to improve their cognitive skills of mathematical problem solving as well as how to develop their metacognitive dimensions. Administrators should hire mathematics teachers who are majors in mathematics education to guarantee content mastery and lesson presentation proficiency. Not anybody should be hired to teach mathematics.

CONCLUSION

In this study, the cognitive skills of the grade six pupils of District 1, Quezon, Bukidnon were at below average level in terms of numerical comprehension, simple linguistic sentences, contextual information, mental visualization, number system knowledge, relevant information, number sense estimation, and procedural calculation but their symbol comprehension skill was at the average level. It revealed the respondents difficulty in processing information, applying knowledge, and changing preferences in order to solve a problem. The pupils had low metacognitive prediction and evaluation dimensions on their cognitive skills. Their metacognitive dimensions were still untapped and not yet developed. There was a significant difference on the prediction and evaluation of the grade six pupils on their cognitive skills. The pupils had higher evaluation than their prediction. Hence, the null hypothesis that there was no significant difference on the prediction and evaluation of the grade six pupils was rejected.

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ISSN 1839-9053