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# Teaching Concepts and Use of High-Order Cognitive Strategies in Mathematics among Secondary School Teachers

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**Abstract:** This study was conducted to identify the level of emphasis of teaching Mathematics on the understanding of concept and high-order cognitive strategies. A total of 15 teachers from four schools in Pasir Gudang, Johor were selected as respondents. Selected teachers were teachers who teach Mathematics for form two students. The instrument used in this study was a checklist with a 5-point Likert scale and an interview protocol. This checklist has two parts, part A on the background of the respondents and part B on the observation of respondents while teaching which contained 21 items. Data obtained from observations were analyzed using descriptive statistics such as mean, frequency and percentage. The findings from the interview were also analyzed to help the researchers make an explanation. The findings showed that the mean of teacher emphasis on understanding the concept and meaning in teaching Mathematics was moderate (m = 2.98). The teachersemphasis on the use of high-order cognitive strategies in the teaching of Mathematics was also moderate (m = 2.79). These findings have implications for Mathematics teachers to always have effective teaching strategies and can help to improve higher-order thinking skills in students.

**Key words:** Teaching concept, cognitive strategies, Mathematics teacher, understanding of concepts, implication

## INTRODUCTION

The goals of the new curriculum are to develop amathematical-minded individuals. The individual should be able to apply knowledge of Mathematics effectively. In addition, individuals can also solve problems and make decisions in line with the development of science and technology. However, Ball *et al*. (2001) stated that the curriculum and teaching methods used in school focuses on skills and procedure only without allowing them to appreciate the power of Mathematics. The current way of teaching Mathematics focuses on drilling and remembering facts which does not encourage thinking and problem solving (Abdullah *et al*., 2014). Thus, the role of a teacher is very important in the classroom. The quality of education that teachers provide to student is dependent on what teachers do in the classroom (Zakaria and Iksan, 2007).

Teachers have a central role to play in building a useful knowledge base for the profession (Stigler and Hiebert, 2004). According to Stigler and Hiebert (2004) to improve teaching, most current efforts should focus on methods that teachers use in the classroom. The teaching of Mathematics in class should emphasize conceptual understanding. Among the areas that should be emphasized is the understanding of the concept of number, shape and space and the relevant application of Mathematics to solve problems in various situations.

The development of problem solving skills also need to be addressed during the teaching process, other than thelogical development of thinking skills as well as systematic and creative reasoning skills to produce individuals who can think logically and rationally. However, there are issues that arise such as the extent to which teachers emphasize conceptual understanding in Mathematics teaching. Secondly, the extent to which teachers emphasize the higher-order cognitive strategies in teaching Mathematics. Recognizing the importance of understanding the concepts in the teaching of Mathematics, a study should be done to determine the extent to which teachers emphasize conceptual understanding in Mathematics teaching in secondary schools.

**Teaching of mathematical concepts:** In this study, the teaching of concept by a teacher is teaching that promotes understanding of mathematical concepts. This means that a teacher needs to understand and master mathematical concepts well before teaching the topic. Shiyyab stated that concepts and mathematical rules need to be linked with other disciplines as

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well. Thus, when teachers teach mathematical concept the teacher should not only define and explain mathematical concepts but also should give appropriate examples. Teachers also need to ensure that the concept is used to form a new concept to be mastered by the student before teaching a new concept. Rittle and Koedinger (2009) also noted that the students should be exposed to the concept of Mathematics in a variety of forms, methods and approaches. In addition, teachers should use effective teaching strategies to enhance the understanding of the concepts in Mathematics teaching. Griffin and Jitendra (2009) suggests some mathematical problem solving strategies to enhance the understanding of mathematical concepts. Among them are give concrete examples to make generalizations of conceptual understanding in Mathematics, give different examples that are related, give examples that have nothing to do with the concept being taught to create difference and generalization, provide various types of mathematical examples to get the right concept.

Erickson further stated that the concept of teaching refers to teachers' understanding of a concept. If teachers themselves do not understand the concepts, then it is difficult to carry out the transfer of knowledge and deep understanding.

**High order cognitive strategy:** In this study, high order cognitive strategy is referred to as the use of principles or procedures that involve higher order thinking skills of teachers in the teaching of Mathematics to improve the knowledge and skills of students in Mathematics. The procedure that can help improve cognitive strategies among teachers is the teacher apply various form of problem-solving strategies. In addition, teachers create problems in the form of an open and difficult problem to solve and provide opportunities for students to build their own knowledge by asking their understanding of mathematical concepts. Supramani states that teachers should give students the opportunity to answer questions that is challenging. Through these questions the students are free to find a solution to a problem. They are involve in decision-making and give their views to the teacher and other students. This high-order cognitive strategies are also associated with the level of Bloom's Taxonomy (Anderson *et al*., 2001) that is the level of analysis, synthesis and evaluation.

## MATERIALS AND METHODS

For this study, a total of 15 Form 2 Mathematics teachers wasselected to participate in the study. The method used in the study was a systematic observation methods in which natural events were selected, recorded and described by observers who are not participants of the study. Researchers also used a video recorder and a checklist to record observations. This checklist contains items that will be evaluated by the researcher and a space is provided to note the behaviour seen. Instrument used in this study was adapted from Shiyyab.

The researchers also used interview to get more information about respondents. In this study, structured interview was used where the interview was conducted in a formal, carefully planned and implemented in accordance with a list of questions to be answered by the respondents. The researchers asked the respondents based on a list of questions that have been constructed. Before the actual study was done, researchers conducted a pilot study to look at the suitability of the items in the checklist. The validity of the instrument was assessed by experts in the field of Mathematics education. Inter-rater agreement were also used.

## RESULTS AND DISCUSSION

**Meaning and conceptual understanding in Mathematics teaching:** The mean for teachers emphasizing meaning and conceptual understanding in Mathematics teaching was moderate, 2.98 (Table 1).

**High-order cognitive strategies in the teaching of Mathematics:** Based on Table 2, the average mean of high-ordercognitive strategies in the teaching of Mathematics is moderate, 2.79.

The mean of emphasis on meaning and understanding of Mathematics is moderate. The emphasis on concept by teachers in the teaching of Mathematics is how teachers can convey mathematical concepts in a meaningful way. Meaningful presentation exists when teachers convey mathematical concepts to students and students respond or interact with teachers. Meaning Theory stated that student interaction with the environment can improve students' understanding of the concepts.

However, there are some respondents who are less focused on emphasizing the concept to students. In line with the findings of Shiyyab which reported that teachers still lack in emphasizing on meaning and understanding of the concepts in the teaching of Mathematics. This shows a conventional form of teaching is still practiced whereby the teacher is the sole knowledge giver. This is also consistent with the findings of Subahan which showed that most teachers are more comfortable using the blackboard in the teaching of Mathematics. The findings of Abdul Razak and Nor Asmah further strengthen

Table 1: Distribution of frequency (percentage) and the mean for the concept

| | Frequency (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| Understanding of concept | 1 | 2 | 3 | 4 | 5 | Mean | Level |
| Communicate that Mathematics problem cannot always be solved quickly | 0 | 5 | 3 | 7 | 0 | 3.13 | Moderate |
| Communicate that some problems have more than one answer | 3 | 3 | 4 | 5 | 0 | 2.73 | Moderate |
| Focus on what students know rather than what they do not know | 0 | 2 | 4 | 9 | 0 | 3.33 | Moderate |
| Using informal assessments to provide feedback to students | 0 | 1 | 4 | 10 | 0 | 3.60 | High |
| Mathematics is useful and makes sense | 4 | 3 | 3 | 5 | 0 | 2.60 | Low |
| Mathematical processes are used in context rather than in isolation | 4 | 5 | 4 | 2 | 0 | 2.27 | Low |
| Emphasizes understanding of mathematical concepts | 2 | 1 | 7 | 5 | 0 | 3.00 | Moderate |
| Provide opportunity to use the new concept | 2 | 1 | 4 | 8 | 0 | 3.20 | Moderate |
| Providing the opportunity to restate and formulate problems | 2 | 1 | 8 | 4 | 0 | 2.93 | Moderate |
| Providing the opportunity to ask questions, consider different possibilities | 1 | 2 | 9 | 3 | 0 | 2.93 | Moderate |
| Mathematics is expressed through pictures, diagrams, graphs, word, symbol or numerical examples | 0 | 0 | 7 | 8 | 0 | 3.53 | High |
| Using a variety of mathematical tools, models, manipulatives, calculator or computer | 3 | 6 | 2 | 4 | 0 | 2.47 | Low |
| Provide opportunities for students to plan to invent or design of mathematical ideas, projects, activities, or products | 2 | 0 | 9 | 4 | 0 | 3.00 | Moderate |
| Mean | | | | | | 2.98 | Moderate |

Table 2: Distribution of frequency (percentage) and the mean of cognitive strategies

| | Frequency (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| High order cognitive strategy | 1 | 2 | 3 | 4 | 5 | Mean | Level |
| Teachers helpsstudents to formulate and refine hypotheses | 3 | 2 | 7 | 3 | 0 | 2.67 | Moderate |
| Opportunities are given to collect and organize data and information | 0 | 2 | 7 | 6 | 0 | 3.27 | Moderate |
| Teachers help students to learn and practice a variety of strategies for doing Mathematics | 4 | 3 | 3 | 5 | 0 | 2.60 | Low |
| Teachers encourage students to reflect their own problem solving methods and strategies | 0 | 2 | 8 | 5 | 0 | 3.20 | Moderate |
| Students are asked to explain concept orally or in writing | 1 | 1 | 4 | 9 | 0 | 3.40 | Moderate |
| Opportunities are given to work with open ended problem | 3 | 4 | 5 | 3 | 0 | 2.53 | Low |
| Opportunities are given to work with poorly defined real-life problems | 10 | 1 | 1 | 3 | 0 | 1.80 | very low |
| Students are provided situation in which they enjoy doing Mathematics | 2 | 3 | 5 | 5 | 0 | 2.87 | Moderate |
| Overall Mean | | | | | | 2.79 | Moderate |

*(1 = not present, 2 = implied but not explicitly present, 3 = present and used, 4 = used in an insightful manner; room to expand, 5 = developed and used; understanding the obvious)

the above statement in which most teachers still difficult to determine the appropriate method for teaching Mathematics. However, teachers nowadays need to be more sensitive to the needs of students and the appropriate teaching methods engage students in Mathematics.

Mathematical concepts is also associated with the use of teaching aids. The use of teaching aids help teachers master the mathematical concepts more effectively while helping students improve their understanding of concepts. The findings of Abu and Eu (2014) demonstrates the use of teaching aids by teachers to improve student achievement in Mathematics in addition to enhancing interest of students towards Mathematics.

However, most respondents are not using teaching aids in teaching. This finding is consistent with findings from interviews before observation where only a few respondents were meticulously planned to provide training materials and substances such as geometry.

However, there are respondents who were interviewed did not state clearly about their plan before teaching, although respondents use compasses and protractors. They give reason of not enough time to use teaching aids in the classroom. Only a few respondents stated that use of teaching aids such as using compasses in geometry. They also reported teacher workload as reason for them not using teaching aids. In line with the findings Ahmad and Tamuri (2010) showed that teachers cannot implement the use of teaching aids in because of its workload is too heavy. This means that teachers need to wisely manage their time by dividing the tasks carried out in school or job as educators to educate the nation's children.

The mean for teachers emphasizing the use of high-order cognitive strategies in the teaching of Mathematics is also moderate. In this study, most respondents give students the opportunity to verbally explain Mathematical concepts however, the concept describes by the students shows the students do not really understand the concept. This is because students are just repeating what the teacher said. A clear understanding of concept is when students use their own words to explain the concept. Yildiz *et al*. (2010) reported that students who understand concepts will restate the concept that has been studied and can relate the concept

with various other mathematical concepts. Teachers are using high-ordercognitive strategies but not fully utilize their use. Teachers should ask students to use their own words on what they know about the concept. This situation can train students to think and generate ideas to restate these concepts in their own words.

The use of high-order cognitive strategies, also viewed through open problems to students. Open problems can be defined as teachers give students the opportunity to use other ways to solve math problems. Most respondents do not practice open problem in the teaching of Mathematics. Most Mathematics problems given by respondents are focused only one solution only. Respondents were only asked students to use methods that have been shown only. This indicates the respondent does not provide opportunity for students to develop their cognitive or express their own ideas. In contrast to the study of Abdul Razak and Nor Asmah showed that teachers give students the opportunity to express their ideas in the teaching Mathematics.

Teachers should give students opportunity to solve math problems without using the existing solution. This can further enhance their skills in solving mathematical problems as well as enhance their cognitive skills.

The emphasis of teachers on the use of higher order cognitive strategies is related toteachers' use of difficult problem to solve in Mathematics. In solving difficult problems, some barriers are encountered. In this study, only a handful of respondents who use difficult problem and the rest do not use difficult problem in the teaching. Most questions or problems given by respondents are text book based and lower order type of question. Thus, teachers should create difficult problems to train students to think at a higher cognitive level such as synthesis and evaluation type of problems. This means that teachers need to explore various forms of math problems before teaching the students.

## CONCLUSION

Overall, the emphasis towards understanding the concept and use of high-order cognitive strategies in the teaching of Mathematics is moderate. Teachers should communicate that some problems have more than one answer and that Mathematics is useful and make sense. During teaching, Mathematical processes are used in context rather than in isolation. Teachers should use a variety of Mathematical tools, models, manipulatives, calculator or computer. Teachers need to provide opportunity for students to be actively involved in activities to solve open problems and poorly defined real-life problems.

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