QUALITATIVE TECHNIQUES IN METACOGNITION IN PHYSICS PROBLEM SOLVING AMONG SECONDARY SCHOOLS STUDENTS IN JOHOR BAHRU, JOHOR, MALAYSIA

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Abstract: Researches in metacognition in problem solving have always been an issue among cognitive and education researchers. This is due to the quantitative methods using questionnaires which are unable to represent the actual metacognitive processes carried out by the secondary students. Thus, this research has been carried out to compare both the quantitative and qualitative techniques in determining the metacognitive skills in physics problem solving among the secondary school students in Johor Bahru, Johor, Malaysia. Five students achieving the highest scores on both the Physics Problems Solving Ability Test (PPSAT) and the Metacognitive Skills Questionnaire (MSQ) were selected to be reassessed using the qualitative techniques. The qualitative techniques are thinking aloud protocol, interviews and analysis of the paper & pencil test by the students. The cross tabulation and triangulation techniques were implied and the results were later being compared with the pass researches found in the literature. The result showed that qualitative techniques not just produced stronger conclusion but also gave the insight of how the metacognitive skills assist the students in solving Physics problems that could lead to the initial building of a Physics problem solving model from the perspective of metacognition.

Keywords: Metacognition, Metacognitive Skills, Thinking Aloud Protocol, Physics Problem Solving.

1 INTRODUCTION

In the process of teaching and learning of Physics, the measurement of the knowledge gained by the students can only be discovered through assessment. The process of assessing Physics achievement for Malaysian secondary students is carried out in the form of public examinations such as the Sijil Pelajaran Malaysia (SPM) or the Malaysian Certificate of Education (MCE), taken at the end of Form 5, after two years of higher secondary education. More than 50% of the whole examinations is about problem solving where Paper 3 of this public examinations is totally on problem solving (Lembaga Peperiksaan Malaysia, 2003). According to the Physics Syllabus (Pusat Perkembangan Kurikulum, 2002), the fourth objective of the subject is about problem solving. Hence, problem solving in Physics is an important part of the process of teaching and learning. In view of the above, a study on metacognition and problem solving is undertaken.
Metacognition refers to knowledge and cognition about cognitive phenomena (Flavell, 1979). It is the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective (Flavell, 1976). It is believed to play an important role in many oral comprehension, reading comprehension, writing, language, acquisition, perception, attention and self-control (Flavell, 1985). Metacognition includes knowledge about general cognitive strategies and knowledge about monitoring, evaluating and regulating these strategies (Jausovec, 1994).

Metacognitive skills have been identified as a strategy to solve Physics problems and should be taught to the students to help them solve Physics problems (Mestre, 2001). The bombastic word of “metacognition” was introduced by Flavell in the 70s (Flavell et al., 1993) and its roles in educational research include metamemory, language, communication, perception, observation, understanding and problem solving (Flavell, 1999). The role of metacognition in problem solving has been proven by many researchers (Kluwe, 1982; Swanson, 1990; Kuppusamy, 1992; Schoenfeld, 1992; Jausovec, 1994; Runco & Chand, 1994; DeGrave et al., 1996; Yeap, 1998; Nooriza Kassim, 2001; Halina Kasmani, 2003; Kuo, 2004).

In the research of metacognition, many researchers agreed that the measurement of metacognitive knowledge, skills and components are not at all easy (Rowe, 1991; Jausovec, 1994; Manning & Payne, 1996; Metcalfe, 1996). According to Rowe (1991), measurements of learning outcomes can show whether a student has acquired certain facts, rules and procedures but these do not provide any information about the way which the assessed knowledge and skills have been acquired nor even tell us what prevented a certain individual from developing the required knowledge or skills. According to Jausovec (1994), the main difficulty in the metacognition in problem solving research is that of assessing metacognition while the individual solves problem. The methodological shortcoming may seriously bias research on metacognition.

The approach of research can be divided mainly into two, which are the quantitative approach and the qualitative approach. Through literature reviews, both approaches were widely used in the metacognition researches.

2 METHODOLOGY

The main purpose of this research is to investigate the role of metacognitive skills, which consist of monitoring skill, evaluating skill and regulating skill, in assisting the Form 4 students in solving Physics problems. Basically, there are two phases in this research. The first phase is to determine five respondents within a sample with the highest ability in Physics problem solving among a pool of Form 4 students in Johor Bahru. The second phase is to identify the role of metacognitive skills in helping these respondents solve the problem. The first phase consists of a paper-and-pencil test of Physics Problem Solving Ability Test (PPSAT), related to the topic of Linear Motions, and questionnaire of Metacognitive Skills Questionnaire (MSQ) which contains 27 Likert Scale items divided into three sections to measure monitoring skill, evaluating skill and regulating skill.

From 389 samples, only five with the highest score in PPSAT and MSQ were chosen to the second phase to participate in the qualitative part of this research. These respondents were purposely chosen for an in-depth study on the role of metacognitive skills in assisting them to be good problem solvers. Metacognitive skills cannot be solely measured by using only questionnaire. According to Rowe (1991), the concern of relying on self-report was raised as to the extent to which information is accessible to a person’s awareness, when metacognition is talking about the awareness of the cognitive processes. In measuring metacognitive skills, Rowe (1991) suggested 2 methods which are the direct and indirect methods. The direct methods are self reports, questionnaires, interviews, thinking aloud protocol while the indirect methods are
certainty of response, training of short-term memory, simulation, peer teaching and cross-age tutoring, ranking and rating methodologies.

In this research, the direct methods were implemented. Through triangulation technique which comprised the thinking aloud protocol, interview, questionnaire and the paper and pencil test, the role of metacognitive skills were measured. Triangulation is a good technique in providing more valid results in cognitive behavior. Researches in metacognition generally used various kinds of instruments (Rowe, 1991). Thus, many suggestions and techniques are used in these researches while the most popular technique is the thinking aloud protocol. This technique provides a kind of concurrent self-report (Rowe, 1991).

The thinking aloud protocol is widely used in the metacognitive researches such as researches in mathematics problem solving (Yeap, 1998; Nooriza, 2001), general problem solving (Swanson, 1990; Jausovec, 1994; DeGrave et al., 1996). Briefly, the subject is required to express verbally all thoughts, reactions, feelings and so on that come into his or her mind during task performance such as while solving a problem (Rowe, 1991). These expressions are recorded and analyzed later to identify the metacognitive skills involved.

The interview session started immediately after the respondent had finished the thinking aloud protocol, that is when the respondent come to the end of the problem solving. It is important to interview the respondent as close as to the task performance in order to ensure that the information elicited should come directly from their short term memory (Rowe, 1991). The open-ended questions which were similar with the MSQ were used in the interviews to gain similar situation from more sources than the questionnaire. Besides enhancing the validity of the self-reports, the interviews encourage the respondents to give more information about their cognitive behavior which might not be spelled out during the thinking aloud protocol. Some of the questions were taken from Charles et al. (1992) which are relevant to the evaluation of problem solving.

All the data from the MSQ, thinking aloud protocol, interviews and answer sheets was analyzed qualitatively. A set of coding to indicate different metacognitive skills were used for the items of MSQ using the alphabet P for the monitoring skills, N for the evaluating skills and A for the regulating skills. These codes were noted in the transcript of the thinking aloud protocol, transcript of interview and answer sheets. All these were then cross tabulated and arranged in a table for each respondent in order to determine the patterns of metacognitive skills involved in problem solving.

3 FINDINGS

The verbatim records of the thinking aloud were translated into transcripts for each of the respondents. There were two sets of problems to be solved by each of the respondents. The metacognitive skills’ coding which is taken directly from the MSQ was noted next to the sentences of the thinking aloud indicating that metacognitive skills were being uttered by the respondents. The answers of the interviews as well as the answers of the paper and pencil test were also being noted with similar coding. The patterns of the coding representing the respondents’ metacognitive skills were arranged in the form of a table, cross tabulating the results of the MSQ, the coding of thinking aloud protocol, interviews and paper & pencil test for each respondent. Five different tables were obtained. Table 1 shows one of the table for the first respondent.

For the items in MSQ (representing the metacognitive skills) which the respondents rated as ‘definitely yes’, these metacognitive skills were likely to be appeared frequently in the thinking aloud protocol and were then agreed by the respondents when quite the similar questions were being asked. For example, for the item ‘While reading the question, I translated it into a different
form’ that is coded as A4 (metacognitive skill), the first respondent rated himself ‘5’ which means ‘definitely yes’ and in the thinking aloud protocol, immediately after he had finished reading the first question, he mentioned,

5 Oh, stopped
6 Write it down first
7 Constant decrease of velocity
8 Drop from 30 meter per second to 15 meter per second in a distance of 75 meter
9 Ok, distance, s
10 Draw the diagram first (A4)
11 Ok

Of course in the paper & pencil test, a simple diagram of the movement of the object was drawn. The transcript of the interview also indicated the same idea when in question number 3, he was asked whether he liked to imagine or draw the description of the problem, he answered that he usually makes imaginations if he is short of time, but he preferred drawing it because it gave him clearer and more precise situation of the problem.

<table>
<thead>
<tr>
<th>Code</th>
<th>MSQ Score</th>
<th>Thinking Aloud</th>
<th>Interview</th>
<th>Answer Sheet</th>
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<tbody>
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<td>P2</td>
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Table 1: The cross tabulation table of metacognitive skills of the first respondent for all the qualitative instruments.
By thinking of your imagination or the thinking of the images within your mind, you are actually using the metacognitive skills. You are regulating your thinking to figure out the meanings of the text problem and try to change it into another format which you know that you will understand it better. Here is where the metacognitive skills of regulating play their roles in helping the students to solve these Physics problems.

There were five of these cross-tabulation tables for each of the respondents. All the five respondents have the same full-score for their PPSAT but the respondents with higher score in MSQ (indicating the metacognitive skills) showed more metacognitive skill of regulating especially in the thinking aloud protocol and also in the interview. The respondents with higher score in MSQ also solved problem faster. Table 2 shows the some qualitative summary of each metacognitive skill involved in assisting the respondents to solve Physics problems.

4 SUMMARY

The quantitative results only gave the surface conclusion of the positive role of metacognitive skills. But, by analyzing the data qualitatively, the results showed clearly in which step of problem solving do the specific metacognitive skills appear to be helpful. The qualitative results also gives a stronger and more in-depth answers of how and which metacognitive skills really contribute in helping the students to solve Physics problems.

As what Pressley & McCormick (1995) said, the qualitative research is very helpful in constructing theories such as developing a grounded theory, the in-depth analysis of the qualitative data also lead to an initial model of problem solving in Physics from the perspective of metacognition. Figure 1 is the initial results from the interpretation of the patterns of the qualitative data in Physics problem solving among the Form Four Science students in Johor Bahru, Johor, Malaysia.

The experience of using the qualitative techniques in the Physics problem solving research helps the researchers to make a stronger conclusion on the role of metacognitive skills in helping the Form Four Science students in solving Physics problems. In the quantitative part, the coefficient correlation of each of the metacognitive skills with that of problem solving is positive and significant but quite weak, which is between .150 to .300 (Fatin Aliah & Seth). This result does not elucidate the researchers in making the conclusion as to where and how did these metacognitive skills assist the students in solving Physics problems until the results of qualitative data were interpreted in a more systematic form using tables and the techniques of triangulation as well as cross tabulation.

In order to validate and test the initial model in Figure 1, an extension of this research is being carried out in the whole state of Johor, Malaysia with a stratified sample of Form Four Science students representing the population of the state. This project is being funded by the Research Management Center (RMC) of Universiti Teknologi Malaysia. (UTM).
<table>
<thead>
<tr>
<th>Respon-dent 1</th>
<th>Monitoring Skill</th>
<th>Evaluating Skill</th>
<th>Regulating Skill</th>
</tr>
</thead>
</table>
| Time taken: 13.14min | - Always ask questions to himself to stay focus to the problem  
- Talking actively to himself | - less in evaluating and checking  
- can explain the answer well  
- think back and revise the problem after solving it  
- consider the logics of the answer | - regulating frequently  
- self-explain the problem  
- consider the meanings of the problem to search for the goals.  
- try to recall similar problem  
- translate problem to another format  
- choose and arrange data  
- consider needed and unneeded data  
- write down the data |
| MSQ Score: 129 | - less in monitoring  
- read and reread the problem for better understanding | - check the solution after finish answering  
- check answer, equation, calculation and steps  
- can explain the answer well  
- revise difficult problems | - regulating frequently  
- consider the meanings of the problem to search for the goals.  
- try to recall similar problem (make notes)  
- translate problem to another format (Chinese)  
- choose and arrange data  
- write down the data |
| Respon-dent 2 | Monitoring Skill | Evaluating Skill | Regulating Skill |
| Time taken: 25.16min | - Always ask questions to himself to stay focus to the problem  
- Talking actively to himself  
- Try more then 1 way  
- Monitor the progress of solution | - check answer, equation, calculation and steps  
- can explain the answer well  
- revise difficult problems  
- consider the logics of the answer | - less in regulating  
- consider the meanings of the problem to choose and arrange data  
- translate problem to another format  
- write down the data |
| MSQ: 127 | - less in monitoring  
- read and reread the problem for better understanding | - check the solution after finish answering  
- check answer, equation, calculation and steps  
- can explain the answer well | - regulating frequently  
- consider the meanings of the problem to search for the goals.  
- consider needed and unneeded data  
- translate problem to another format (symbol)  
- write down the data |
| Respon-dent 3 | Monitoring Skill | Evaluating Skill | Regulating Skill |
| Time taken: 31.12min | - Always ask questions to himself to stay focus to the problem  
- Talking actively to himself  
- Try more then 1 way  
- Monitor the progress of solution | - check answer, equation, calculation and steps  
- can explain the answer well  
- consider the logics of the answer | - less in regulating  
- consider the meanings of the problem to choose and arrange data  
- translate problem to another format  
- write down the data |
| MSQ: 126 | - less in monitoring  
- read and reread the problem for better understanding | - check the solution after finish answering  
- check answer, equation, calculation and steps  
- can explain the answer well | - regulating frequently  
- consider the meanings of the problem to search for the goals.  
- consider needed and unneeded data  
- translate problem to another format (symbol)  
- write down the data |
| Respon-dent 4 | Monitoring Skill | Evaluating Skill | Regulating Skill |
| Time taken: 14.01min | - Monitoring frequently  
- Always ask questions to himself to stay focus to the problem  
- Talking actively to himself  
- read and reread difficult problem  
- Try more then 1 way  
- Monitor the progress of solution | - less in evaluating and checking  
- can explain the answer well  
- think back and revise the problem after solving it  
- consider the logics of the answer | - regulating frequently  
- consider the meanings of the problem to search for the goals.  
- consider needed and unneeded data  
- translate problem to another format (symbol)  
- write down the data |
| MSQ: 120 | - less in monitoring  
- read and reread the problem for better understanding | - check the solution after finish answering  
- check answer, equation, calculation and steps  
- can explain the answer well | - regulating frequently  
- consider the meanings of the problem to search for the goals.  
- consider needed and unneeded data  
- translate problem to another format (symbol)  
- write down the data |
| Respon-dent 5 | Monitoring Skill | Evaluating Skill | Regulating Skill |
| Time taken: 15.31min | - Monitoring frequently  
- Always ask questions to himself to stay focus to the problem  
- Talking actively to himself  
- read and reread difficult problem  
- Try more then 1 way  
- Monitor the progress of solution | - less in evaluating and checking  
- can explain the answer well  
- think back and revise the problem after solving it  
- consider the logics of the answer | - regulating frequently  
- consider the meanings of the problem to search for the goals.  
- consider needed and unneeded data  
- translate problem to another format (symbol)  
- write down the data |
| MSQ: 117 | - Monitoring frequently  
- Always ask questions to himself to stay focus to the problem  
- Talking actively to himself  
- read and reread difficult problem  
- Try more then 1 way  
- Monitor the progress of solution | - less in evaluating and checking  
- can explain the answer well  
- think back and revise the problem after solving it  
- consider the logics of the answer | - regulating frequently  
- consider the meanings of the problem to search for the goals.  
- consider needed and unneeded data  
- translate problem to another format (symbol)  
- write down the data |

Table 2: The summary of the result of qualitative analysis
Figure 1: An initial model of Physics problem solving from the perspective of metacognition, built from the qualitative analysis.

REFERENCES


