How do Primary School Students Acquire the Skill of Making Hypothesis

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ABSTRACT

Science education in Malaysia emphasizes three components: namely knowledge, scientific skills which include science process skills, and manipulative skills, and scientific attitudes and noble values. The science process skills are important in enhancing students' cognitive development and also to facilitate students' active participation during the teaching and learning process. This study is aimed at identifying the acquisition of the skill of formulating hypothesis among primary school students. It was conducted based on the theory of neo-Piagetian Cognitive Development and was investigated using generic qualitative research method. Three data collection techniques were used comprising observation, interviews and document analysis. Two tasks were developed and given to students as a stimulus during interviews: which are "Acquisition -Skill Stimulus" (RPK) and "Compilations of Experiment related Questions" (HiSET). Six primary school students were selected as participants based on purposive sampling. Based on the data analysis, four major categories emerged, namely: (a) the concept of hypothesis, (b) identification of the effect of variable, (c) the relationship between variables, and (d) testing of hypothesis. Initial findings illustrated that the mastery level of hypothesis formulation in three participants was very low, while the mastery level in the others was noticeably low.

Keywords: *science process skills, formulating hypothesis, primary school.*

INTRODUCTION

Science education in Malaysia emphasizes three main components; knowledge, scientific skills which are scientific process skills and manipulative skills; and scientific attitude and positive values. Scientific skills comprise seven basic science process skills; observation, classification, measurement, making predictions, inferences, communication, and time and space relationship. In addition, there are five integrated science process skills; interpreting data, defining operationally, controlling variables, formulating hypothesis and experimentation. The acquisition of integrated scientific skills among primary school students depends on the acquisition of the more basic scientific skills (Corrigan, 1998). Therefore, it is vital for a student to master the basic science process skills before advancing to the integrated ones.

Scientific skills are a set of specific skills that assist students in learning science, getting them to be more actively involved, and consciously expand their capabilities. The skills are similar skills that are utilized by scientists in their research. Bredderman (1983) defines scientific skills as a cognitive skill that can be used to understand and disseminate information. If students are not exposed to these skills in a systematic, logical and chronological manner, they run the risk of learning the skill through simple rote-learning and memorization. They will in turn face difficulties in mastering and developing this skill at a higher level.

The importance of mastering science process skills is apparent through various studies performed domestically and internationally. Many studies have focused on students' active participation during science lessons, and emphasis on the mastery of science process skills (Abraham & Millar, 2008). According to Johnston (2009), mastery of science process skills is also related to cognitive growth; as noted by Chin and Kayalvizhi (2005) mastery of these skills stimulates higher order thinking skills. Studies have also looked into students' aptitude in accruing the skill of formulating hypotheses (e.g. Braund and Hames, 2005).

Although numerous studies have been undertaken in the area of science process skills, specific studies on formulating hypothesis are rather limited, especially in Malaysia. The mastery of hypothesis formulating skill depends on the ability to comprehend the basic skills, and also the ability to manipulate variables. The skill of formulating hypothesis is defined as:

.....the ability to form general statements on the relationship between a variable that is thought to be true, in explaining an occurrence or matter, whereby the statements' veracity can be tested. (Kementerian Pendidikan Malaysia, 2003)

The acquisition of this skill makes science a meaningful subject since it is very much related to our daily life (Akinbobola, 2006). It encourages logical and rational thinking; promotes higher order thinking, and it is also linked with problem solving ability (Akinbobola & Afolabi, 2010). In the process of coming up with a hypothesis, a student will draw on his or her ability to assess, that is to assess whether a particular hypothesis is true or vice versa. It is in this act of making an assessment that students use their logical and rational thinking. This clearly illustrates that formulating hypothesis is closely linked to thinking skills. Most studies that dwelt on the science process skills have been focused mostly on students' learning at secondary level. Furthermore, a significant number of previous studies on the mastery of science process skills employed the quantitative approach.

Thus this study is aimed at exploring the primary school students' acquisition of the skill of formulating hypothesis. Specifically, this study seeks to answer the following research questions:

1. What is the primary school children's understanding of the concept of hypothesis?

2. What is the level of mastery of these school children in formulating hypothesis?

RESEARCH METHODOLOGY

The present study is part of a larger study and it employed the qualitative research approach, specifically the phenomenography method. Phenomenography is designed to answer questions regarding thought and learning, especially in the context of education research (Marton, 1986). An individual's experience becomes a subject of research by focusing specifically the details of the multiplicity of their experience. It is undeniable that each individual is different and experiences learning, for example, in a unique way (Wan Zah Wan Ali, 2004). The phenomenography method is deemed to be the most appropriate research method in the context of this research. It can describe the phenomenon of acquiring the skill of formulating hypotheses from the view point of a student; through his or her various experiences in learning science.

This study was conducted in a primary school in the district of Kota Bharu, Kelantan. The school has three Year Six classes. This is a typical primary school with a basic science room that is used as the science laboratory. Three female students; Masyhitah, Balqis, and Hidayah (all pseudonyms) and three male students; Nasrullah, Qayyum and Mukhlis (also pseudonyms) were involved in this study. They were all in the same class, were of the same age (12 years old) and ranged from low to average in their achievement level.

The data collection process took four months. As the subjects were Year Six students, data collection could only be performed after the Primary School Assessment Examination (commonly known as UPSR). However, two meetings have been successfully arranged with the students, outside of school hours. The topic "Investigating the Force' was chosen in this study. The topic was chosen as there were a variety of experiments that can be conducted that involved the skill of formulating hypothesis. In order to answer the research questions, various data collection methods were employed which include observation, interview and document analysis.

Observation

Observation was conducted on the subjects while they were conducting experiments which were based on the Mastery Stimulus task or in short RPK. RPK is a series of task designed by the researcher. It comprised experiment procedures that involved formulating hypotheses, the execution of the experiments, students making observation on the experiments, collection of experiments' data, discussion and conclusion. The students need to complete a structured laboratory report and this report also served as data. These data were used to gauge the students' ability to formulate hypotheses.

Each subject was made to conduct two experiments with the first being the measurement of time; designated by RPK 1, and the second was the recording of temperature known as RPK 2. Important events that occurred while the

subjects were conducting these experiments were recorded in the fieldnotes. Students performing the experiments were also video recorded to ensure all data were captured.

Interview

After conducting the experiments, the subjects were made to complete the second task; i.e.the **Additional Experiment Questions (known as HiSET)**, before being interviewed. HiSET was made up of questions based on four experiments of four different science topics. The interviews were conducted in a semi-structured manner. Although the interview protocol had been prepared prior to it, new findings during the observation necessitated an update to the interview protocol. The interviews were conducted on the subjects until sufficient data to answer the research questions were collected. On average, two interviews were conducted for each student.

Analysis of Document

Students' feedback on the RPK and HiSET were also used as data. Apart from HiSET and RPK, the subjects were also asked to note down in their journal focusing on the ability to formulate hypotheses, as soon as they finished conducting the experiments and answering the HiSET questions. The entries represented their level of understanding on the ability to formulate hypotheses. In order to elicit more authentic responses from the subjects, they were given the choice to make their entries using either in essay form, or drawings.

Data Analysis

The data were gathered and managed using NVivo 8. The data were analyzed using the constant comparative method of analysis. The process began with coding. Approximately 103 codes emerged. After the screening and cleaning process, some of those codes were eliminated and merged to form new codes, which in turn produced the themes and categories. However, this paper will only discuss four main categories that emerged in the initial findings, to represent the students' mastery of the skill of formulating hypothesis.

FINDINGS

Four main categories emerged in this study are (a) the concept of hypothesis, (b) the effects of variables, (ci) the relationship between variables, and (d) testing of hypothesis.

The Concept of Hypothesis

The findings indicate that all of the subjects did not fully comprehend the concept of hypothesis. Most of the students had the idea that a hypothesis is formulated after an experiment is conducted. As for Mukhlis, although he stated that hypothesis is formulated before an experiment is conducted, he did not state that it is wrong for hypotheses to be formulated after an experiment is conducted. Meanwhile, Nasrullah could not explain why hypotheses must be formulated before conducting an experiment;

Researcher : Are hypotheses formed before or after an experiment?

Nasrullah : After

Researcher : After an experiment. So it is wrong for a hypothesis to be made before the experiment?

Nasrullah : It's wrong

B263 –B268? TB1/SR/Nasrullah

Another notion that illustrates that the students had a vague concept of the skill is the confusion between formulating hypothesis with making conclusion;

Researcher : What do you understand with the skill of formulating hypotheses?

Nasrullah : The ability to come up with a conclusion

Researcher : The ability to come up with a conclusion. So when do we form conclusions?

Nasrullah : When we want to conclude it

Researcher : To conclude what?

Nasrullah : To conclude an experiment.

TB1/SR/Nasrullah/274 – 280

The findings also revealed that majority of the subjects failed to grasp the concept of variable. The concept of variable is fundamental for the skill of formulating hypothesis. The important ideas in the concept of variable are naming the types of variable, stating the number of variables, determining the specific variable in any experiment, explaining the variables, differentiating one variable from another and explaining the functions of the variables according to its types. The students who failed to grasp the concept of variable also failed to understand the concept of hypothesis. This can be illustrated in the following interview excerpts:

Researcher : What must be present when making a hypothesis?

Mashitah : There must be a change and can be observed

TB1/SR/Mashitah/148-152

Researcher : What do you understand about formulating hypotheses? What must we do to form a hypothesis?

Nasrullah : Identify the change.

Researcher : Come again?

Nasrullah : Identify the change.

Researcher : Oh, identify the change, okay, what's next?

Nasrullah : Measure, .. ah … record the temperature

Researcher : Then? What comes after the change and the measure?

Nasrullah : We come up with the conclusion

Researcher : We come up with the conclusion? What's the difference between conclusion and making hypothesis?

Nasrullah : Errr, I mean we come up with the hypothesis

Researcher : Which one comes first?

Nasrullah : Errr…. I'm not sure.

Researcher : Which one comes first, the conclusion or the hypothesis?

Nasrullah : The conclusion comes first…… correction…. I'm not sure.

TB1/SR/Nasrullah/150 -167

From these excerpts, it is evident that these students have not grasped the concept of variable, and that they were confused between variable and hypothesis; and confused between variable and conclusion. Therefore it can be concluded that the students' understanding of the basic concepts of the skill of formulating hypothesis is weak.

Stating the Effects on Variables

The second category emerged is the students' ability to predict the effects on variable onto another variable. The findings indicated that not only were the students unable to differentiate and match the variables and the type of variables, they also failed to show that they understand the effect dependent variables have over independent variables. This is shown in the following excerpt:

Researcher : What are we measuring?

Nasrullah : The difference in time

Researcher : What causes the difference in time?

Nasrullah : The number of pendulum swings

Researcher : What is the effect of the number of swings has over the time?

Nasrullah : Errrr (Silence).

Researcher : You changed the time or the number of swings

Nasrullah : I'm not sure, teacher

B220-B228/TB1/SR/Nasrullah

The excerpt indicates that Nasrullah was unable to relate one variable with another. In this scenario, the number of pendulum swings should affect the time taken, whereas he explained the opposite. The same is indicated by the other students.

Relationship between Manipulating Variables and the Formulating Hypotheses

The third category emerged from the data analysis is the ability to state the relationship between the skill of manipulating the variables and formulating hypotheses. One of the important components in the ability to formulate hypotheses is the ability to state the relationship between variables; and then formulate the hypothesis. The findings show that the students were unable to identify the variables and to label the types of variables. They were not able to relate between the dependent and independent variable in the assigned task, as indicated in the next excerpt:

Researcher : What's the relationship between the number of metal cubes and the increase in the level of water?

Iqbal : (Silence)

Researcher : What is being measured?

Iqbal : Err.... Water temperature

Researcher : State the relationship between the number of cubes and the level of water

Iqbal : I don't know

B355 – B361/TB1/SR/Iqbal

This interview excerpt clearly shows that Iqbal was unable to identify the relationship between the independent variable (metal cubes) and the dependent variable (the volume of water displaced). This lead to the student's difficulty in coming up with a hypothesis statement.

Making a general statement regarding the relationship between variables is a characteristic of the ability to

formulate hypotheses (KPM, 2003), but the research findings show that the subjects were unable to form a hypothesis, and were unable to state a statement that is hypothetical in nature from one that is not. The subjects indicated that they had memorized in order to identify a hypothesis; either by identifying for the "**if-then**" or the phrase **"the higher the …"**. Statements that do not contain these words were not considered as hypotheses. This shows the inability to formulate hypotheses for the assigned tasks, as illustrated by Iqbal:

The temperature increases with the increase in the temperature, and it decreases upon cooling.

The 'hotter' the heat, the higher is the water temperature.

RPK2/SR/Iqbal/Bah. B/S1

Testing a Hypothesis

The validity of a hypothesis must be tested with an experiment. But the findings also show that the students were unable to relate between a hypothesis and proving it in an experiment. The responses given by the subjects were " … have not heard about it", , or " … knew about it but I can't really explain the term **hypothesis confirmed or disproved**". All the subjects were not able to state whether their hypotheses were confirmed or disproved based on the experiments conducted:

Researcher :What is the relationship between a hypothesis and an experiment?

Amira : I don't know

Researcher : What is a hypothesis testing?

Amira : I don't know

Researcher : Can a hypothesis be tested?

Amira : It can't

B70 –B76/TB2/SR/ Amira

DISCUSSION AND CONCLUSION

In general, the initial findings of this research indicate that the ability to formulate hypotheses among primary school students is low. Their basic concept of the skill is weak. They could not identify the variables of any given experiment, they also could not relate between variables even though these skills are fundamental to the skill of formulating hypothesis. The findings also reveal that some of the students memorized statements related to formulating hypotheses. In fact, they were able to provide the correct answer for some situations, but not for the rest. In other words, their mastery of hypothesis formulation is not consistent probably due to the memorization syndrome. In addition, they also lack the ability to correctly explain their answers.

The findings also show that the components in the ability to formulate hypotheses are interrelated and connected with one another hierarchically. The subjects did not show continuity in their understanding of the smaller components of the skill of formulating hypothesis. Students should understand the concept of variables, the effect of one variable onto other variables, and the relationship between variables. Only then can they formulate the hypothesis.

Mastery of the hypothesis concept, including understanding the concept of hypothesis and variable, is able to help students to explain and understand the effect one variable has over another, state the relationships between variables, gain the ability to formulate hypotheses, to differentiate a hypothetical statement from a non-hypothetical statement, and to determine whether a hypothesis can be tested to ascertain its plausibility. Therefore primary school students' mastery of the ability to formulate hypotheses depends on their understanding of that particular skill's sub component. The subjects' unstructured thought and comprehension also contribute to their weak ability to formulate hypotheses. In learning science, scientific concepts and skills are related. Therefore, the subjects' ability to formulate hypotheses is dependent on their comprehension of scientific concepts. The mastery of basic scientific concepts takes place in multiple stages beginning from the basic scientific processes. Therefore the ability to formulate hypotheses relies on these basic processes (Corrigan, 1998; Park, 2006).

It is well established that the ability to formulate hypotheses, is an important component in science learning (Abraham & Millar, 2008). But the findings showed that this mastery among primary school students is somewhat low.

Some students merely memorized and regurgitated, no more than that, although there should be no shortcuts in acquiring the skill to formulate hypotheses. The skill should be emphasized from young; which is as early as in primary school as it takes more than simple fact memorization. Therefore the teaching and learning of science must promote students' mastery of hypothesis formulation beginning with the basic sub-skill moving to more complex skills. These findings could provide some guidance to teachers on developing the skill of making hypothesis among students.

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