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Phenomenographic Study of Students' Manipulative Skills During Transition from Primary to Secondary School

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Abstract

Manipulative skills include skills in handling materials and apparatus in the context of scientific investigation. Students lack exposure in "hands-on" activities at primary school lead to insufficient manipulative skills and they may carry this problem with them to secondary school. This problem will pose a greater problem during school transition. School transition is a challenging process for students whereby they have to adapt with social issues to fit into their new environment. This study resulted from a longitudinal study with the implementation of phenomenographic research design. The research was administered to 10 primary school students (Year Six) and they were re-interviewed in secondary school (Form One). Students' capability in handling thermometer, measuring cylinder, Bunsen burner and microscope were observed in order to get comprehensive understanding of students' manipulative skills during the process of transition from primary to secondary school. Findings revealed that students have not fully developed the basic skills in using and handling scientific apparatus. Five (5) categories of description emerged from data that represented the nature of the students' manipulative skills, namely: (1) non-systematic operation of tasks, (2) non-effective management of time and workplace, (3) haphazard safety and precautionary measures, (4) poor technical skills, and (5) problem in numeracy and drawing specimen.

Keywords: Transition from primary to secondary school; progression in science learning; manipulative skills; science psychomotor skills; phenomenography

Abstrak

Kemahiran manipulatif merupakan kemahiran yang merangkumi kebolehan dalam mengendalikan bahan dan alat radas, serta kemampuan untuk mematuhi arahan dan membuat pemerhatian yang tepat. Kurang pendedahan terhadap aktiviti "hands-on" di sekolah rendah boleh membawa masalah dalam penguasaan kemahiran manipulatif dan masalah ini akan berlanjutan khususnya semasa transisi ke sekolah menengah. Transisi adalah satu proses yang mencabar bagi murid di mana mereka perlu menghadapi pelbagai isu sosial semasa menyesuaikan diri dengan persekitaran baru. Kajian ini merupakan kajian jangka panjang yang mengaplikasikan pelaksanaan reka bentuk penyelidikan fenomenografi. Penyelidikan telah dijalankan terhadap 10 orang murid sekolah rendah (Tahun Enam) dan mereka ditemubual semula di sekolah menengah (Tingkatan Satu). Pemerhatian terhadap kebolehan murid dalam menggunakan termometer, silinder penyukat, penunu Bunsen dan mikroskop telah dijalankan untuk mendapat pemahaman komprehensif tentang kemahiran manipulatif mereka semasa proses transisi ini. Dapatan kajian menunjukkan murid masih belum menguasai kemahiran asas pelajar dalam mengendalikan peralatan saintifik. Berdasarkan analisis, lima kategori telah diperolehi iaitu: (i) Operasi kerja yang tidak sistematik, (2) Pengurusan masa dan persekitaran kerja yang tidak efektif, (3) langkah berjaga-jaga dan keselamatan yang tidak cermat, (4) kemahiran teknikal yang lemah, dan (5) Masalah dalam melukis spesimen dan numerasi.

Kata kunci: Transisi dari sekolah rendah ke sekolah menengah; progresi dalam pembelajaran sains; kemahiran manipulative; kemahiran psikomotor dalam sains; fenomenografi

1.0 INTRODUCTION

One of the important goals of science education is to develop the technical and the intellectual skills needed to pursue study in science related courses. Science experiences for the intermediate grades should focus on the use of hands-on experiences with gradual development of the ability to conduct a true experiment (Wolfinger, 2000). Conversely, teaching and learning of science

was more on retention of knowledge (Galton, 2003; Hawk & Hill, 2004; Rohaida Mohd Saat, 2010). The understanding of science was to be achieved in the first place not by reading about theories but by performing experiments and creating concepts at first hand in the laboratory. Science experiment and practical work are what pupils look forward to most in secondary school science and it holds the key to maintaining positive attitudes to science (Braund et.al, 2003).

Problems with capability in science manipulative skills can seriously get in the way of other desirable skills in the laboratory. Students struggling to operate a piece of apparatus may fail to make important observations and gather poor data. Thus, it is essential for students' to establish the manipulative skills so that they can go on auto-pilot and free the student's attention for other things such as observation and accurate recording (Anderson *et al*., 1970; Johnstone & Al-Shuaili, 2001).Students lack exposure of hands-on activities at primary level could lead to students lack acquisition of manipulative skills at secondary level.

Numerous studies have shown a significance negative impact on students' attitudes and attainment towards science learning during transition from primary to secondary school (between 11 to 14 years old) (e.g. Diack, 2009; Thurston *et al*., 2010). For science subject, this phenomenon can be exhibited by the decline in achievement and eroded interest in learning science (Braund *et al*., 2003; Galton, Gray & Ruddock, 2003). Transition should be viewed as a process that takes time for the students to adjust themselves in. Although most of the pupils experience a smooth and successful transitioning and able to adapt to their new learning environment, some of them find that transition is very difficult and problematic especially for those who are considered to be 'at-risk' student. Transition is particularly stressful, often serving to lower self-esteem which in turn lowers school achievement (Hurd, 2000). If this trend is not reversed, it will give a negative impact on students' attitudes and attainment towards learning, and may affect the incidence of school drop-outs in our country.

In Malaysia, research in science manipulative skills is still limited and much can be done to improve students' manipulative skills. The development of student manipulative skills in the context of school transition is one of the settings that have not been given much interest in the field of science education. In general, the aim of this study is to explore and investigate the acquisition of students' manipulative skills during the transition from primary school (Year Six) to secondary school (Form One) by implementing qualitative research methodology.

■2.0 RESEARCH METHODOLOGY

This study adopted the phenomenography research design which aim to define the different ways in which people experience, interpret, understand, perceive or contextualize a phenomenon or certain aspect of reality and directed towards experiential description (Marton, 1996; Orgill & Sutherland, 2010). Phenomenography is an empirical research tradition that designed to investigate the qualitative different ways in thinking and learning, especially in the context of educational research, where it is originated from. In this study, the difference ways in performing manipulative skills has been scrutinized to get an understanding of the main phenomenon.

The study was conducted to obtain an in-depth understanding of students' manipulative skills during transition from primary to secondary school by looking at the students' capability in handling Bunsen burner, thermometer, microscope and measuring cylinder. These apparatus have been chosen based on analytical analysis of Year Four, Year Five, Year Six (primary school) and Form One (secondary school) science practical textbooks. The four (4) apparatus have been introduced to students at primary level and these apparatus are considered fundamentals in performing laboratory activities later in secondary school science.

This study involved 10 students through their transition from two primary schools to three secondary schools in the district of Gombak. The study was conducted throughout Year Six (primary school) and Form One (secondary school). The students participated in this longitudinal study with the consent from their parents and guardians. Purposeful sampling has been utilized in obtaining the participants for this study.

2.1 Methods of Data Collection

The collection of data involved two main phases. The first phase was conducted at two primary schools. Year Six students were analysed individually on their capability and skills in handling thermometer, microscope, Bunsen burner and measuring cylinders by conducting two experiments. Direct observation is the most appropriate method to understand manipulative skills, where students are needed to exhibit the skills to assessor. Video recordings have been used during the execution of the tasks to assist researcher during the observation. This was followed by a semi-structured interview to determine issues experienced by students during the transition and their perception about the process of transition in learning science. In this interview, students justified their skills in handling the apparatus based on their performance during the execution of experiments.

The second phase of this study was done to the same students when they have moved to the secondary school. Again, the students have to demonstrate their manipulative skills in using Bunsen burner, thermometer, microscope and measuring cylinders. Students were re-interviewed to explore their experience in performing laboratory activities in secondary school.

2.2 Data Analysis

The phenomenographic analysis for this study started with the analysis of raw data from the fieldwork. All recorded materials were transcribed into text data. The transcription of interviews, observations and fieldnotes were explored and analysed thoroughly in order to obtain general sense of the data and to get immersed in it which Morton and Booth (1997) refer as "a pool of meaning". The researcher obtained an overview of the richness and diversity of the gathered materials through the process of familiarization. During this stage, the researcher read through the transcripts, watched the recorded observation, studied the field notes and listed the main ideas and initial codes, as suggested by Ritchie and Spencer (1994). The draft of categories of description was constructed and developed over a period of iteration which may supported the rigour of the phenomenographic analysis as suggested by Akerlind, Bowden and Green (2005).

■3.0 FINDINGS

Based on the analysis of the observations and interviews with students five different categories emerged and the categories represent various ways of the students' understanding of manipulative skills. This categorization (refer to Figure 1) describes the collective understanding of the students' manipulative skills

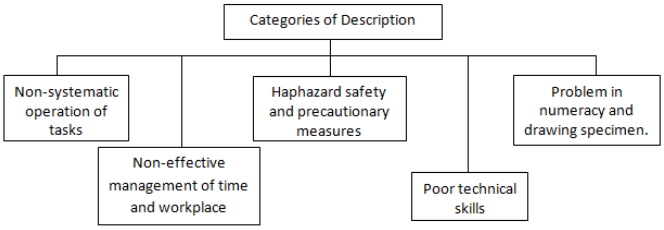

Figure 1 Categories of description

3.1 Descriptions of Categories

3.1.1 Manipulative Skills as a Non-systematic Operation of Tasks

In the first category, manipulative skills involved the students' inability to follow instruction and failure in checking the apparatus for functionality in order to perform a systematic operation of tasks. Some students have difficulties to follow simple instruction during the execution of experiment. However, these students showed much progress at secondary school in the aspect of ensuring the functionality during experiment especially when it comes to the used of Bunsen burner. It can be observed during the task execution of Student 7:

> He turned the gas knob a little more and the flame got bigger. He checked on the flame consistently while waiting for the water to boil (Obs3, Eps2, S7b).

3.1.2 Manipulative Skills as Non-effective Management of Time and Workplace

The second category refers to manipulative skills that related to the students' inefficiency in using time, untidiness of working area and the practice of cleaning and storing of apparatus. Efficiency in this context can be defined as the students' ability to conduct the task immediately and in orderly manner to get the best results. During transition the students did not show much efficiency in this category of manipulative skills. This can be observed from the following excerpts of Student 6 when he was asked to take the temperature of boiling water:

> He made his eyes parallel to the meniscus and read the temperature. Meor put the thermometer down. After a short second he picked up the thermometer again and immersed it back into the beaker (Obs1, Ep 5, S6a).

Tidiness of working area focused on the students' attitude to ensure that their working area appearance was orderly and neat, specifically in the placement of apparatus during experiment. The following excerpt was the observation from Student 1 when he was ready to take the first measurement of the water:

> How can I read this?" Student 1 mumbled to himself. It was difficult for him to read the thermometer because the apparatus was set quite far from the end of his laboratory table (Obs1, Eps3, S1a).

In the aspect of cleansing and storing of apparatus, most of the students were able to demonstrate good skill at primary school and they transfer the good practises to secondary school.

3.1.3 Manipulative Skills as a Haphazard Safety and Precautionary Measures

Most of the students demonstrated dangerous techniques in carrying out experiment in the laboratory which can be damaging to themselves and people around them. For example the following quotes illustrate the manner in which students handled the Bunsen burner during experiment:

> He (Student 4) stirred the solution until all the salt dissolved. He observed the boiling water, too near; his face was directly above the beaker. The researcher has to stop him from doing that (Eps4, Obs3, S4b)

> He (Student 10) waited for the water to boil and once in a while he touched the beaker to feel the hotness of it. The researcher asked him to stop doing that in case he injured his fingers (Eps2, Obs3, S10b).

The incautious handling of apparatus by the students can also be damaging to the apparatus. Despite being given chances to use thermometer at primary school, most of the students failed to demonstrate appropriate safety skills in handling it.

3.1.4 Manipulative Skills as a Poor Technical Skill

In the fourth category, manipulative skills can be interpreted as four (4) different sub-categorizes of technical skills which involved the correct handling of apparatus during experiment. The sub-categories are (a) ability to recognize apparatus and its function, (b) problem in identifying part of apparatus and its function, (c) inappropriate application of apparatus and (d) improper manipulative techniques and sequence in using apparatus.

The first and second sub-categories emerged based on the interviews with the students during transition. Students did not encounter difficulties in recognizing the apparatus and its function. However to identify each part of apparatus and its own function were a challenge to them especially when it comes to more complex apparatus such as Bunsen burner and microscope. Identifying part of apparatus is important for students' to understand the safety information in using apparatus for safe execution of experimental procedure. The problem in recognizing the basic function of apparatus such as Bunsen burner will affect the students' awareness of the necessary precautionary actions that need to be taken while using it.

The fourth sub-category which deal with manipulative techniques in handling the apparatus is the most complex sub-category. It dealt with the sequential used of Bunsen burner and microscope, and measuring technique in using measuring cylinder and thermometer. From here it was observed that the students' unsatisfying skills in handling Bunsen burner especially in manipulating the air hole to obtain complete combustion. The students' ability in using microscope was varied. Some of the students did not even know the correct technique in using the adjustment knob for example:

> Student 4 started her observation of specimen under the 40x magnification lens (highest power). She rotated the nosepiece and used the 4x magnification lens. She told the researcher she cannot see anything. He researcher noticed that did not use the coarse adjustment knob at all until her friend asked her to adjust the knob (Obs4, Eps2, S4b).

3.1.5 Problem in Numeracy and Drawing Specimens

The fifth category of description includes making assumption, error in measuring and the skills in drawing specimens. From the interview they admitted that it has been common practice for them to consider the initial reading of any measurement as 'zero'. From the observation almost all of the primary and secondary school students in this research assumed that the initial temperature of water was 0ºC.

Based on the observation during transition, students still have difficulties to practise the correct procedure of reading meniscus. Students ensured that their eye position is at the same level of the meniscus to avoid parallax error but they tend to read the upper meniscus of the liquid. This problem will also affect their ability in using measuring cylinder and other complex measuring apparatus such as burette and pipette. Many will argue that this sub-category is not within the context of manipulative skills. However from the practical aspect, the measuring skill in Science Process Skills is inseparable with manipulative skills, for examples, Moni *et al*. (2007) listed "to perform accurate measurement" as a component of manipulative skills in the lab and Doran, Fraser and Giddings (1995) listed measuring and manipulating as specific skills in the same category, 'Performing'.

The students showed different abilities in drawing specimens. Most of the students drew the specimen similar to what they have observed in text book. Figure 1 and 2 displayed the example of the students' hypothetical drawing of onion cells:

Figure 1 (Obs2, S7b)

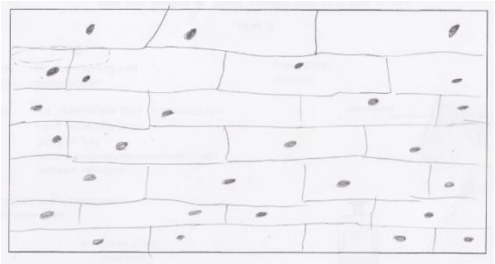

Figure 2 (Obs2, S9b)

4.0 DISCUSSION AND CONCLUSION

From this study, manipulative skills can be understood by analysing the five categories of description which involved (a) non-systematic operation of tasks, (b) non-systematic management of time and workplace, (c) haphazard safety and precautionary measures, (d) poor technical skills, and (e) problems in numeracy and drawing specimens.

Systematic operation of tasks is important to understand the students' methodical ability during scientific experiment. Students should be able to conduct the experiment systematically and from here we might be able to recognize the student's ability to come out with acceptable working procedures on the basis of limited instructions in the laboratory. This will lead to the smooth execution of experiments during the transition from primary to secondary school. Efficiency may be achieved if the students can bring themselves to the automation stage which requires continuous practices and repetition of skills. The acquisition of these skills is important to ensure a smooth execution of experiment and essential for the students to avoid damage to the apparatus, to themselves, to other people and the environment. This research has also shown that these students were too concerned about getting the right answer rather than to develop their observational skills during experiment especially when they needed to draw the specimens. This might occur due to the ascendancy of theoretical content of science. Teacher wants the students to observe the 'right thing' and somehow has affected the students' development of observational skills. Consequently these students tend to draw the right answer which they have learned theoretically.

We can assume that student may have hard time when they first use the scientific apparatus. However with repetition and practises, this task can be performed automatically and required minimum attention as they have already acquired the skills proficiently. From the observation we can often notice how these students lose their way in experiment because they were engrossed in mastering the details of using the apparatus. All the skills performed by the students reflected their procedural understanding which has been constructed from their theoretical knowledge from declarative stage.

Findings clearly showed that the students' manipulative skills can be enhanced and improved much further and their lack of skills were probably due to our current practices which give too much emphasize on retention of knowledge. This factor may hinder students' progress in obtaining the automation stage whereby recurrence and repetition of this learning process were considered as essential elements for the acquisition of manipulative skills. Study has shown a gap in the acquisition of manipulative skills during transition in which the primary school science and secondary school science has been considered as two different entities.

From the observation we can conclude that primary school teacher did not give much emphasis on learning manipulative skills, then again secondary school teacher expected that these students have some prior knowledge in using the apparatus which stems from the students' previous experience at primary school. Thus there is a need for us to come out with a bridging programme that can create a liaison between primary and secondary schools science in order to facilitate successful adjustment of a school transition.

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