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THE NATURE OF COGNITIVE PROCESSING AMONG STUDENTS IN SCHOOL SCIENCE LABORATORIES

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The nature of cognitive processing among students in school science laboratories has become an important issue in the effectiveness of teaching and learning chemistry. Although it has strong impact on the quality and amount of learning, but there has been little research to date. The purpose of this study is to ascertain the nature of cognitive processing that occurs in student interactions during chemistry practical lessons. Three chemistry teachers with their students from national schools in the Southern West Coast of Sabah, Malaysia were involved in this study. Three chemistry practical lessons were observed, and were audio and video taped. Data were analysed and coded based on a well-known framework for sociocultural discourse analysis. Findings shown that three categories of cognitive processing identified were 'procedural processing' (60.0%), 'exploratory/interpretative processing' (25.0%) and 'off task' (15.0%). 'Procedural processing' played a main role in most of the observed interactions in the lab, often found in activities which focused on handling, organizing, and executing experimental tasks. Meanwhile, 'exploratory/interpretative processing' were found in activities focused on planning, hypothesis testing, evaluation and exploring experimental alternatives. Contrary, 'off-task' found in activities which not focused on the task such as playing around and chatting. The research findings will provide insights and practical guidance to teachers and researchers which behaviours facilitate or hinder learning during small groups activities in the laboratory.

INTRODUCTION

Over the years, laboratory work has been viewed as a crucial aspect in science education. Many educators and researchers have suggested its importance in science education. For example, many teachers perceive its use as the basic modus operandi for the teaching of science (Abrahams & Reiss, 2012). In fact, studies revealed that effective laboratory work allow students to understand better between what they can see and handle (hands-on), and develop scientific skills thorough their observations (Woodley, 2009). In addition, some researches claimed that laboratory work leads to better learning (Millar, 2010). Other benefits of laboratory work have well documented in the literature. (Hofstein, Kipnis & Abrahams, 2013; di Fuccia, 2012; Kennedy, 2012; Kidman, 2012; Mamlok-Naaman & Barnea, 2012; Toplis & Allen, 2012; Millar & Abrahams, 2009; Hofstein & Mamlok-Naaman, 2007). For most school science in Malaysia, chemistry teachers practice cooperative learning, in which they divide students into small groups for experimentations. Studies have shown that peer interactions play a vital role in the teaching and

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learning of chemistry (Sim & Mohamad, 2014). This is particularly true in cooperative learning implementations, in which interpersonal interaction is considered a central component of learning process.

Systematic observation of students working together can provide better understanding of the behaviours that occur during cooperative small-group learning (Poulsen et al., 1995). Similar studies have claimed that cooperative learning is an alternative to traditional practices, in which, it fosters students' interactions in group's work (Effandi & Zanaton, 2007) and provides opportunities for students to communicate effectively in small groups, and develop skills and attitudes among students (Hofstein, Kipnis & Abrahams, 2013; Davies, 2008; Curriculum Development Centre, 2005).

However, till today very few research investigate students cognitive processing in Malaysia school science practical work. In fact, poor performance in practical work has been seriously questioned recently (Siti, 2014; Ministry of Education, 2013). Studies have shown that effective cognitive processing will exhibit the process of learning in which learning occur when students inquire and communicate effectively while go through the process of hands-on activities (Sim & Mohamad, 2014).

But, in this study, we focused our research on cognitive processing, which is related to the person conducting the experiment, affects the students' learning and achievement, regardless of the method of the experiment. It examines how students approach their learning tasks as problem solvers. Three categories of cognitive processing, namely exploratory/interpretative processing, procedural processing and off-task will be investigated in details.

OBJECTIVE

This study attempts to investigate the nature of cognitive processing that occurs in student interactions during chemistry practical lessons.

METHODOLOGY

A qualitative descriptive research was employed in this study. According to Shields and Rangarajan (2013), a qualitative descriptive research is used to describe population phenomenon being studied. The utmost goal is to improve practice. Such study design is seen useful to build an in-depth and contextualized understanding about complex issues in the social context (Yin, 2003).

Research Samples

The study was conducted in three national schools in the southern west coast division of Sabah, Malaysia. Three chemistry teachers with their students were participated in this study as voluntary basis. These chemistry teachers were selected using purposive sampling technique. Their age were ranged from 32 to 48 years old.

Data Collection

Three chemistry practical lessons were observed, and were audio and video taped.

Data Analysis

All data collected were coded using qualitative approach based on a well-established framework for sociocultural discourse analysis (Kumpulainen & Mutanen, 1999). In particular, actions or words captured in video-taped or field notes were carefully analyzed to infer students' cognitive processing into common categories of cognitive processing, 'exploratory/interpretative processing' (activity focused on planning, hypothesis testing, evaluation, and experimenting), 'procedural processing' (activity focused on handling, organizing, and executing), or 'off-task' (activity not related to the task, e.g. playing around or chatting).

RESULTS AND DISCUSSION

In this section, we describe the nature of students' cognitive processing and its characteristics in peer group activity. We restrict our description to changes in the three cognitive processing categories, which were commonly observed in different labs. Findings revealed that procedural processing played a central role in most of the observed interactions in the lab. Overall, 60.0% of all of the coded events associated with activities in which students were focused on handling, organizing, or executing experimental tasks (see Table 1, Table 2, Table 3 and Table 4). Only 25.0% of the coded events were related to exploratory/interpretative processing, in which students focused on planning, hypothesis testing, evaluation and

TABLE 1: STUDENT INTERACTIONS FOR THE GROUP ENGAGED IN THE CHEMISTRY PRACTICAL LESSON BY CHEMISTRY TEACHER 1

	Events/Oral Interaction	*Cognitive Processing*
S1:	Our aim is to investigate the chemical properties of Group 1 metals in their reactions with water. The materials err… that are needed in this experiment are a small piece of lithium, distilled water, red litmus paper and blue litmus paper. The apparatus needed are water troughs and forceps.	Handling (Procedural Processing)
S2:	First, cut the lithium into a small piece and the remove the oil. Place the lithium slowly onto the water surface by using forceps. Now the reaction is done.	Executing (Procedural Processing)
S1:	We test the solution with a piece of red litmus paper.	Executing (Procedural Processing)
S3	Wow! The red litmus paper turns blue.	Executing (Procedural Processing)
S2	Now we test the solution with a blue litmus paper.	Evaluation (Procedural Processing)
S3	And the blue lit… litmus paper remains …. Unchanged. It has given out the hydrogen gas with a 'hiss' sound.	Hypothesis testing (Exploratory/Interpretative Processing)

experimenting. While, only 15.0% of the coded events indicated off-task, in which students chatting with friends, or playing around. The first excerpt (Table 1) describes the student interactions occur during cooperative group activity in a chemistry practical lesson by chemistry teacher 1.

In this situation, procedural processing is the most dominant in peer group interactions compared to exploratory/interpretative processing and off-task which comprised of 66.67%, 33.33% and 0.0%, respectively (Table 1). Students' activities included in procedural processing mainly focused on handling and organizing experimental task, in which their activity often followed the procedures in the practical manual. On the other hand, exploratory/interpretative processing often focused on activities involved hypothesis testing an evaluation. The students' activity reflects their deep engagement and interest in the problem-solving task. However, none of any off-task activities observed in this practical lesson. These findings correspond with previous studies showing exploratory processing is the determinant of effective collaborative learning (Kumpulainen & Kaartinen, 2000).

TABLE 2: STUDENT INTERACTIONS FOR THE GROUP ENGAGED IN A CHEMISTRY PRACTICAL LESSON BY CHEMISTRY TEACHER 2

	Events/Oral Interaction	*Cognitive Processing*
S1:	We are currently conducting an experiment on the effects of electrodes… here at the positive terminal, I mean the anode is connected to the copper, and negative terminal connected to the iron spoon, which is the cathode…	Organizing (Procedural Processing)
S2:	No worries, I can handle this experiment… the copper should be decreased in size and be transferred to the iron spoon.	Handling (Procedural Processing)
S3:	Any copper on the iron spoon?	Executing (Procedural Processing)
S4:	Yes... a little.	Executing (Procedural Processing)
S3:	Take out eh… I want to see.	Experimenting (Exploratory/ Interpretative)
S2	As you can see the copper being transported into the iron spoon. You can see the spoons turns orange... slightly.	Hypothesis testing (Exploratory/Interpretative
S1:	It's so slow… (S1 was chatting with his friends in other groups).	Chatting (Off-task)

In this situation, procedural processing comprised of 57.14%, followed by exploratory/interpretative processing, 28.57% and off-task, 14.29% (Table 2). Apart from students' activities such as hypothesis testing, students' activities involving experimenting were also observed in exploratory/interpretative processing. Meanwhile, activities focused on handling, organizing and executing were found in procedural processing. However, off-task activities included playing around were observed in this practical lesson. These results correspond to the work of Kumpulainen and Mutanen (1999), who identified students with higher exploratory processing tend to be a great problem solver compared to students with procedural or off-task processing.

TABLE 3: STUDENT INTERACTIONS FOR THE COOPERATIVE GROUP WORK ENGAGED IN A CHEMISTRY PRACTICAL LESSON BY CHEMISTRY TEACHER 3

	Events/Oral Interaction	*Cognitive Processing*
S1:	Okay…so… hi.... this the chemistry group 2 and today we are going to do an experiment to determine the empirical formula of magnesium oxide. So we have a must plan first… we have tripod stand, pipe clay triangle, Bunsen burner, crucible and lid, magnesium, sand paper and tongs.	Planning (Exploratory/ interpretative Processing); Handling (Procedural Processing)
S2:	Weigh a crucible with its lid. Clean a 10 cm length magnesium ribbon with sandpaper to remove the oxide layer on its surface. Weigh the crucible with its lid and content. Heat the crucible strongly without its lid. When the magnesium starts to burn, cover the crucible with its lid	Organizing (Procedural Processing)
S3:	Using a pair of tongs, carefully raise the lid a little at intervals. Allow the crucible with its lid still on to cool to room temperature	Executing (Procedural Processing)
S4:	Weigh the crucible with its lid and content again.	Executing (Procedural Processing)
S1:	Haha… try put the crucible on your hand… see hot or not	Playing around (Off-task)

In this situation, procedural processing is the also the most dominant in peer group interactions followed by off-task and then, exploratory/interpretative processing which comprised of 57.14%, 28.57% and 14.29%, respectively (Table 3). Procedural processing mainly focused on executing, then handling and organizing. On the other hand, exploratory/interpretative processing focused on activities involved planning. The students' activity reflects their deep engagement and interest in the problem-solving task. However, off-task activities such as playing around were observed in this practical lesson. Similar studies were reported in Kumpulainen and Mutannen (1999).

Overall, more than half (60%) of the students' activities focused on procedural processing were focused on handling, organizing and executing. Low percentage of exploratory/interpretative processing in peer interactions reflects low engagement and interest in practical work. Findings indicated that students possessed science process skills and manipulative skills but lack of critical and creative thinking skills (MOE, 2013).

According to our results, there was a decrease in exploratory/interpretative processing compared to procedural processing. This results may lead to poor performance of practical work in chemistry. To bridge the gap, special attention need to be taken to improve the cognitive processing among students in southern west coast of Sabah, Malaysia. Hence, this study provide further information for educators who tend to improve their laboratory teaching.

TABLE 4: CATEGORIES AND THE CHARACTERISTICS OF THE NATURE OF STUDENTS COGNITIVE PROCESSING IN PEER GROUP ACTIVITY IN THREE DIFFERENT CHEMISTRY PRACTICAL LESSONS

Chemistry Teacher (CT)	*Cognitive Processing*								
	Exploratory/interpretative processing				*Procedural processing*			*Off-task*	
	Planning	*Hypothesis testing*	*Evaluation*	*Experimenting*	*Handling*	*Organizing*	*Executing*	*Playing around*	*Chatting*
CT1	0	1	1	0	1	0	3	0	0
CT2	0	1	0	1	1	1	2	0	1
CT3	1	0	0	0	1	1	2	2	0
Total	1	2	1	1	3	2	7	2	1
Percentage (%)	5.0	10.0	5.0	5.0	15.0	10.0	35.0	10.0	5.0
Overall (%)	25.0				60.0			15.0	

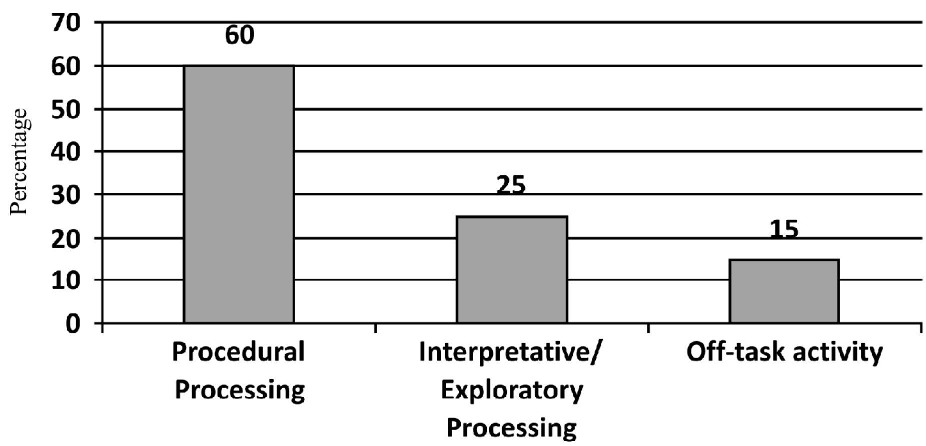

Figure 1: Percentage of Students' Cognitive Processing Occurred in Chemistry Practical Work Percentage

CONCLUSION

Clearly, this study shed some light on the nature of students' cognitive processing in school chemistry laboratories. Findings revealed that three types of cognitive processing identified were procedural processing (60.0%), exploratory/interpretative processing (25.0%) and off-task (15.0%). Findings from this study indicated that 'procedural processing' played a central role in most of the observed interactions in the lab, in which often found in activities focused on handling, organizing, and executing experimental tasks. Meanwhile, 'exploratory/interpretative processing' were found in activities focused on planning, hypothesis testing, evaluation and exploring experimental alternatives. On the other hand, 'off-task' found in activities which not focused on the task such as playing around and chatting. The research findings will provide ideas and practical guidance to educators which behaviours facilitate or hinder learning during cooperative learning in small groups

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