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Development of Procedural Understanding through Constructivist Writing Among Pre-university Students in Laboratory Lesson

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Abstract--- *This study intended to explore how pre-laboratory activity specified in the constructivist writing approach could promote students' development of procedural understanding in the laboratory. A group of 15 pre-university students from one of the Form 6 Centre at the West Coast Division of Sabah was given laboratory work with an inquiry-based strategy. Data was collected from students' writing tasks during the pre-laboratory activity and was triangulated with their conversation during the activity and reflection report. The students' procedural understanding was analyzed with a qualitative method using document analysis of the writing task, reflection report, and conversation analysis. The laboratory lesson is an inquiry-based instruction with an argumentative teaching method on the topic of organic chemistry. The finding shows the pre-laboratory writing tasks, teachers' guidance throughout the lab investigations, and students' prior knowledge have a significant influence on the development of students' procedural understanding. This study suggests emphasizing the constructivist writing approach in the pre-laboratory activity and teachers' guidance for students to enhance their procedural understanding through prior knowledge to solve a scientific problem.*

Keywords--- *Constructivist Writing, Procedural Understanding, Laboratory Lesson.*

I. INTRODUCTION

There has never been so much attention paid to the teaching of thinking and problem solving as there is today. Science education aims to improve students' capability to 'think scientifically' so they can solve problems and appreciate the nature of science. However, the basic issue is that many students are still unable to provide evidence with more than a shallow understanding of concepts that are essential to the subjects they studied [1–3].

Science education indicates the need to involve students with the procedural ideas that are essential to the scientific investigation approach to understanding the nature of science [4, 5]. However, Harrison[6] and Abrahams and Millar[7] noted that laboratory work is less successful in getting the students to use their expected scientific ideas to guide their activities and concentrate on the data they gathered. This phenomenon suggests as though laboratory work to conceptual learning takes place in a different domain [6] and this finding is parallel to other studies that indicate the difficulty in producing students with critical thinking who involve with high-order intellectual activity within science in laboratory work [8, 9] as the practice on its own is inadequate to produce a connection between observation and science concepts [10].

Consequently, constructivist writing strategies are required in science laboratories to engage students to express their thoughts in different ways to build a better framework of scientific knowledge [10–12]. Such approaches are

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concentrate on integrating realistic writing activities instead of seeing writing as a note-taking or filling in form gaps exercises. [13]. The students are interpreting principles of science into their own words and using writing as a way of engaging in thinking.

Laboratory work in the Malaysian learning environment specific to the pre-university STPM often faces similar problems that the laboratory activity is much less efficient for students to understand the procedural ideas they are using to direct their practices. Consequently, for this study, the researcher has introduced a constructivist writing method inspired by Van Duzor [15,16] in the pre-laboratory activity.

II. LITERATURE REVIEW

2.1 Investigation in School Science

Procedural understanding is discussed as the 'thinking behind the doing' [14] where students need to learn the ideas about data collection, analysis, and interpretation before the scientific evidence is effectively treated, and these are known as conceptual evidence. Many students could not make sense of how to analyze scientific evidence, except if the basic concept of evidence is taught in detail [15].

Millar, Lubben, Gott, and Duggan [16] divided the procedural knowledge into three types (Figure 2). Manipulative skills as in the use of apparatuses and the capacity to perform standard techniques that can be learned and developed through practice. The second type applies, for example, to an understanding of the natural surroundings and purpose of inquiry activity. The third type is the understanding of evidence, which refers to the understanding of principles for determining the validity of empirical evidence.

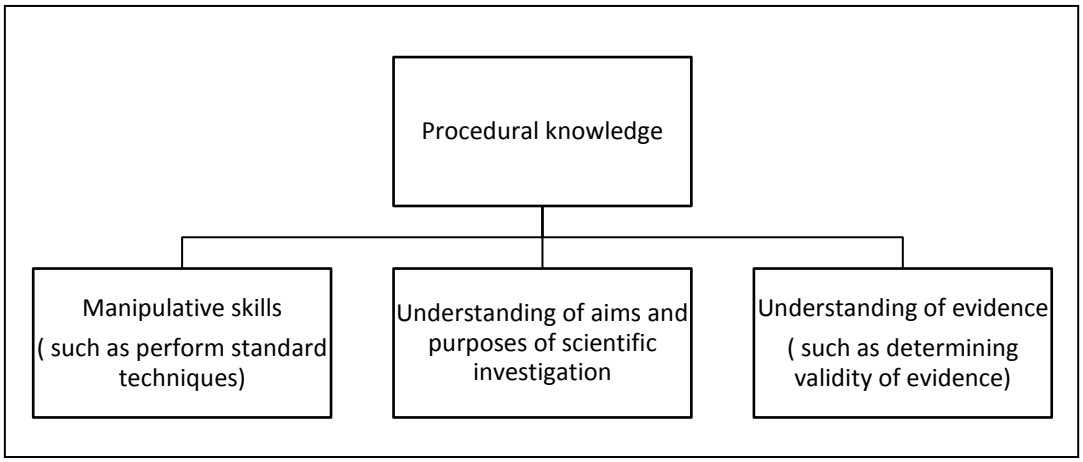

Figure 1: Procedural Knowledge [16]

Students should have the opportunity to master the procedural knowledge. However, science teaching does not emphasize the mastery of procedural knowledge awareness of students, as it has not been seen as an essential part of the process of teaching and learning science [17].

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2.2 Writing in Science Laboratory

Science education has underscored the need to use writing-to-learn approaches in science classrooms. There are three broad categories in writing-to-learn methods; modernist, constructivist, and poststructuralist [18]. Modernist approaches are widely used in school laboratory as their emphasis on writing and reading the scientific, technical language and integrating more traditional laboratory report and notebook formats. Constructivist writing-to-learn methods focus on students translating science concepts into their own words and use student writing as a resource to involve student thinking. Whereas poststructuralist methods are rarely used in science laboratories as they are concerned with students' understanding of the impact of science on society. The three categories can be selected by educators to understand the intended purposes and methodologies of their laboratory writing assignments [19]. It is an opportunity for students to pick up how to write better in science and participate in activities that allow them to understand essential content through writing [20].

III. OBJECTIVE

This study focused on exploring how constructivist writing promotes students' procedural understanding during laboratory work.

IV. METHODOLOGY

This is a study with a qualitative method. A pre-laboratory writing task of an organic chemistry laboratory work was implemented in small group work. The written work was triangulated with participants' conversation during the activity and their reflective writing.

4.1 Research Samples

This study was conducted in a class which consist of 15 students at a Form 6 Centre, West Coast Division of Sabah, Malaysia. These participants were purposefully chosen with fixed categories by the researcher:

- 18 years old of participants.
- Similar intellectual level as they had undergone first-semester examination.

4.2 Research Instruments

There are several data sources for this study. They were the participants' written work from the pre-laboratory writing tasks, audio recordings of the teacher and participants' discourse, and reflective writing at the end of the laboratory lesson. The teacher had the participants gathered into groups. They had to conduct experiments to classify the compounds in two unknown mixtures and deduced as much as they could about the compounds. The teacher has provided the students with a pre-laboratory writing task template. Prompted questions were added in the tasks, such as "Why do you need to add bromine water?". This was planned to serve as scaffolds to demonstrate the types of reactions involved within laboratory testing to students. The teacher and participants' conversation were audio-taped from the beginning of the tasks until the end of the lesson. The students' practical skills were observed, and their conversation throughout the process was audio-taped.

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4.3 Data Analysis

The written documents were analyzed and triangulated with participants' conversation during the activity and their reflective writing at the end of the laboratory lesson. The aim of the document analysis from the pre-lab writing tasks, transcripts of discourse, and reflective writing was to identify cognitive operations.

The texts were coded through reading each participant's pre-lab written tasks, transcripts, and reflective writing seeking emerging cognitive operations. The review process continued until the coding led to the same findings. The relevant findings were grouped in categories, and the interpretations were explained carefully with the suggested meaning. The answers on the prompted questions in the pre-laboratory writing tasks were analyzed before and after the laboratory lesson.

V. RESULT

5.1 Participant's Performance in Writing Task

The participants started by answering prompted questions in the pre-lab writing task. Each participant has completed the task individually and was allowed to negotiate ideas together. At the end of the lesson, their written answers in the tasks before carrying out the laboratory work were compared with their final answers. Their reasoning abilities were detected in their arguments in the group discussion. Their reflective writing at the end of the lesson was coded and categorized.

One of the small groups consists of a pair named Suzie and Vera. Both participants worked well as a team. They both came up with a different style of answers but with similar ideas. In the writing task, they showed rough ideas on the process that they were supposed to investigate in the laboratory and then changed them into better answers at the end of their investigation work.

The tasks were quite complicated. The pair constantly revised their understanding through the teacher's guidance on the tasks as they could not figure out the correct explanation for the observation of their investigations. Nevertheless, they eventually managed to complete their writing task with encouragement from the teacher and then continued with the laboratory investigations.

5.2 Participant's Procedural Knowledge of the Task

The pair's reflective report was reviewed and analyzed together with their conversations and pre-laboratory writing task.

Suzie wrote:

"I honestly not completely understand how to find out the reagent that is used to detect the unknown KA1 and KA2. Some of the reagent used, I barely know the purpose."

"I need to understand the amines chapter first before experimenting. This may help me to recognize the KA1 and KA2 based on the reagent and the purpose of the reagent used. In this way, I will detect the structural or functional group in KA1 and KA2 easier."

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Vera wrote:

"I must understand completely about the theory before starting the experiment. Hence I can know and predict what will happen if KA1 and KA2 react with reagents given."

"My lab partner and I should have more interaction during the discussion part."

The pair mentioned how their prior knowledge could help them to solve their investigation problems. They showed weaknesses in their conceptual evidence even though they did not have problems in their manipulative skills. They also have less interaction as a result of their difficulty in understanding the conceptual evidence during group discussion. The pair has limited conversation until the completion of the laboratory activity. The lab investigation took a long time to finish as the students need more time to discuss their successful and unsuccessful results.

They have learned their mistakes by not being a good observer and gained a slight but significant understanding of the conceptual evidence through the pre-laboratory writing task and guidance by the teacher as this commented by one of the pair;

Vera wrote:

"At first, I was confused about how to distinguish between primary and secondary alcohol but later found out that it was through further oxidation that we can distinguish those two alcohols. Our weakness is not observant enough. "

VI. DISCUSSION

This study finds that the pre-laboratory writing task has an essential influence on the development of procedural understanding. This correlates with the study of Hand[14], Prain and Hand [24] and Van Duzor [12] that described students could use writing to involve with, evaluate, and review their ideas of the scientific phenomena under investigation. The writing tasks should allow students to learn from their mistakes.

Participants' prior knowledge has also given significant results on the development of procedural understanding as there is a connection between conceptual knowledge and procedural knowledge in solving problems [17]. According to Lay [21], the process used in reading and problem-solving environments has a connection to science procedural knowledge. It allows students to have an indirectly better understanding of the concept because they have applied the theory or ideas learned in the laboratory [17]. Therefore students should master both conceptual and procedural knowledge to develop understanding and skills in science.

Teachers' guidance throughout the lab investigations also has crucial roles in the progress of participants' procedural understanding. According to Vygotskian zone of proximal development (ZPD), the teacher's support is the transfer of responsibility from the teacher to students [22] in completing the task. In this situation, scaffolding took place in those collaborations in which the participants were not able to progress in the problem resolution, and the teacher helped them to explain ideas that would inspire them to try to solve the problem [23].

The participants showed less interaction as the result of their difficulty in understanding the conceptual evidence

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as this explained that students would not enter an argumentative discourse when they do not have sufficient knowledge on contents that support the scientific principle of the experiment [24]. This problem is due to their learning difficulties in organic chemistry, which has different terms and terminology and also has varieties of chemical activity compared to other branches of chemistry [25].

The participants have no issues with their manipulative skills as students commonly become better at doing scientific investigations because of the growing experience of investigation in school science. They were collaborating well in the group as Cronin and McCabe [26] described in work with a partner has a significant impact on the enhancement of understanding of the work. This phenomenon shows the accountability of an individual as the students see the benefits from the others' efforts [27]. Students have to be in ZPD to understand the process of an experiment [22] to nurture their knowledge and understanding.

VII. CONCLUSION

This study shows the pre-laboratory writing tasks, teachers' guidance, and students' prior knowledge have an important influence on the development of students' procedural understanding. Conducting a scientific investigation, is mainly shows an understanding of the processes, and not of skill. Therefore practice alone without adding the elements to encourage understanding such as the constructivist writing is not enough to enable students to develop competency in the laboratory work processes. This study suggests emphasizing pre-laboratory activity specified in the constructivist writing approach and teachers' scaffolding in the laboratory activities for students to enhance their procedural understanding in the laboratory.

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