

Using Inquiry Based Module in Chemistry Laboratory Work to Enhance Manipulative Skills

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Abstract

This decade, science and technology education has been given specific attention all at academic level. Malaysia Education Blueprint 2013-2025 states that students must be equipped with the necessary skills to face the challenges of a changing with the application of Science, Technology, Engineering and Mathematics (STEM). This is to meet the need to provide students who competent effectively on a global level. Exposure to scientific skills such as manipulative skills at an early stage is one of the effective methods to provide young people with skills that are very important nowadays. Manipulative skills refer to the ability to use and handle science apparatus and substances correctly while doing an experiment in a laboratory. However, previous studies showing practical work in laboratory are still a host of 'follow the recipe' procedure without the involvement of mental framework or the development of higher-order thinking skills. In other words, the practical work is a 'hands-on' activities rather than 'minds-on'. Recognizing the importance of hands-on laboratory activities for learning science, an approach that is called inquiry based science education (IBSE) approach can help students effectively acquire science process skills. Therefore, this study was conducted to provide added value in teaching in the laboratory through the use of module based on inquiry based science education (IBSE) as it can be an important step to help students to improve the manipulative skills. As this study is at initial phase, in this paper, researcher will explain about the use of inquiry based module in chemistry laboratory work. Researcher hope that this study can contribute to future research on manipulative skills and inquiry based learning especially in chemistry laboratory environment.

Abstrak

Dasawarsa ini, pendidikan sains dan teknologi diberi perhatian mendalam di semua peringkat akademik. Di dalam Pelan Pembangunan Pendidikan Malaysia 2013-2025 menyatakan bahawa murid harus dilengkapi kemahiran yang diperlukan untuk menghadapi cabaran yang sedang berubah dengan pengaplikasian Sains, Teknologi, Kejuruteraan dan Matematik (STEM). Ini adalah bagi memenuhi keperluan untuk menyediakan murid yang kompeten pada peringkat global. Pendedahan kemahiran saintifik iaitu kemahiran manipulatif pada peringkat awal merupakan antara kaedah berkesan bagi menyediakan generasi muda dengan kemahiran yang sangat penting pada masa kini. Kemahiran manipulatif merujuk kepada kebolehan menggunakan peralatan sains serta bahan kimia dengan betul semasa melakukan sesuatu eksperimen. Namun demikian, kajian lepas menunjukkan kerja amali masih lagi merupakan aktiviti 'ikut resipi' yang memerlukan pelajar untuk patuh kepada prosedur, tanpa penglibatan kerangka mental atau perkembangan kemahiran berfikir aras tinggi. Dengan erti kata lain, kerja amali adalah hanya 'hands-on' berbanding 'minds-on'. Menyedari kepentingan aktiviti amali di makmal untuk pembelajaran sains, pendekatan pembelajaran sains berasaskan inkuiri (IBSE) mendapat membantu pelajar secara efektif memperoleh kemahiran proses sains. Oleh itu, kajian ini dilaksanakan untuk memberi nilai tambah dalam pengajaran di makmal melalui penggunaan modul berasaskan pendekatan inkuiri (IBSE) kerana ia boleh menjadi langkah penting yang membantu pelajar untuk meningkatkan kemahiran manipulatif. Dalam kajian peringkat awal ini, penyelidik akan membincangkan tentang penggunaan modul berasaskan inkuiri dalam pembelajaran makmal kimia. Diharapkan juga kajian ini dapat memberi sumbangan dalam kajian lain akan datang mengenai kemahiran manipulatif dan pembelajaran inkuiri khususnya dalam persekitaran pembelajaran makmal kimia.

Keywords: manipulative skills; inquiry-based learning; chemistry laboratory.

1.0 Introduction

Exposure to scientific skills that are science process skills and manipulative skills at an early stage is one of the effective methods to provide young people with skills that are essential nowadays in line with the Malaysia National Education Philosophy with a focus on the individual development to be competitive, dynamic, robust and resilient. With this scientific skill being practiced in the science laboratory, it is capable to train students towards critical thinking, creative and analytical in turn raises motivation and involvement in acquiring scientific knowledge (Tobin & Capie, 1980).

Some of the skills are emphasized in scientific skills is manipulative skills. Manipulative skills refer to the ability to use and handle science apparatus and substances correctly while doing an experiment in a chemistry laboratory (Bahagian Pembangunan Kurikulum, 2012). Good manipulative skills in conducting experiments can polish students' psychomotor skills in which students can use and control apparatus, chemicals and specimens in the correct and proper procedures. These skills are important and can only be achieved with the involvement of students in laboratory activities. After years, the educator

and researcher has proposed a number of benefits obtained when the effective involvement of students in laboratory activities (Hofstein & Lunetta, 2004).

This is because through laboratory activities, scientific phenomenon can be understood by students clearer and more easily. Knowledge, understanding, skills, intellectual and manipulative skills can be instilled through investigative methods such as inquiry learning. Participation in laboratory work can practice manipulative skills better and at the same time can give confidence to the students in handling the chemicals. This could foster scientific attitudes and chemistry learning.

2.0 Literature Review

The focus of science education today is not just to provide a human capital to careers in science and engineering. Around the world, standards of science education emphasize that every citizen should have a basic understanding of science in general and chemistry in particular (Katchevich, Hofstein, & Mamlok-Naaman, 2013). In Malaysia, this requirement also mentioned in the Malaysia Education Blueprint 2013-2025;

‘Our country requires a transformation of its entire education system, lifting achievement for all students. Make no mistake; this will require an entirely new perspective, so that students develop skills needed for the 21st century. Rather than simply adding staff and facilities, there is now a need to understand and improve the dynamics of the teaching and learning process’. (Dato Seri Mohd Najib bin Tun Haji Abdul Razak).

Therefore, creative and innovative teaching curriculum and assessment are proposed to change but still in line with the National Education Philosophy and National Philosophy of Science Education as enshrined in the Chemistry Curriculum Specification (Bahagian Pembangunan Kurikulum, 2012).

2.1 Learning Environment in Chemistry Laboratory

Chemistry is essentially laboratory-oriented subject. Teaching chemistry can be considered as incomplete without practical work (Tafa, 2012). Practical or experimental work must be considered and did not rely on theory alone. Practical work or lab activity has its own role and major in the science curriculum and science researchers have suggested that there are many benefits gained by engaging students in laboratory activities (Hofstein, 2004) .

For many chemistry teacher, practical work such as this is seen as a basic modus operandi for their lessons (Abrahams & Reiss, 2012). As explained by Toplis (2012), practical work is an integral part of 'tradition' in chemistry class. Since chemistry is a branch of science knowledge, the lab is the only place that could develop scientific skills that enable students to make a choice and decision in exploration activities (Feyzİođlu, 2011) and also manipulative skills such as handling equipment and make measurements (Martindill & Wilson, 2015).

Various benefits can be resulted from an effective implementation of laboratory work (Martindill & Wilson, 2015). Study found that students expressed interests in practical work to gain autonomy for personal efforts and seeking cooperation and diversity in learning methods (Osborne, Simon, & Collins, 2003). This is supported by a study of Hofstein & Lunetta (2004) in practical work, students have an exceptional opportunity for dialogue among peers, in addition to the opportunity to work in groups. Review from Hart, Mulhall, Berry, Loughran, & Gunstone (2000) shows that students enjoyed practical work involving the use of apparatus such as Bunsen burners, test tubes and chemicals. Obviously, learning in the science labs have the potential to develop a range of learning skills such as

asking questions, critical thinking and metacognitive skills with a space to collaborate and communicate with friends (Katchevich, 2014).

2.1.1 Issues and Problems in Chemistry Laboratory Work and Manipulative Skills

In Malaysia, a study of manipulative skills in science education is still limited (Fadzil & Saat, 2014) and much remains to be done to improve the practical skills of students in the lab, like many other countries (Abraham & Millar, 2008; di Fuccia, Witteck, Markic, & Eilks, 2012). Emphasis on manipulative skills still lacking in academic teaching, although many important aspects of learning can occur if given due attention (Trowbridge, Bybee & Powell, 2000). According to Dkeidek, Mamlok-Naaman, & Hofstein (2012), laboratory activities definitely have the potential as a learning medium to promote effective learning. But the issue that may arise is the willingness of teachers to teach well in the laboratory.

Among the challenges identified in the implementation of practical work in schools are teachers tend to just do a demonstration. Opinion of the educators that some activities do not need to be implemented in laboratory as in theory can be explained. Furthermore, the constraints of time allocated for carrying out practical work is not enough because the syllabus should be spent more for the exam. These challenges affect the practical work should be carried out by the students who end up distorting the interest and motivation to learn chemistry (Barnea, Dori, & Hofstein, 2010)

Reviews from Johnstone (2006), claimed that educators do not give high expectations toward higher cognitive needs of students in carrying out practical work. With practical work, students had to deal with the abundance of information about equipment, chemicals, instructions about the process of conducting experiments, data, observations and experimental results which led to 'saturation' in memory. Thus, learning in laboratory is much more complex and more difficult than lecture methods in the classroom which is safer and easier. Besides that, the assessment of the practical ability of students and inquiry approach activity also tends to be overlooked until the perception that learning in the laboratory does not carry significant meaning in academic development.

2.1.2 The Importance of Manipulative Skills in Laboratory Work

Manipulative skills refer to the use and handling of chemicals and science equipment while conducting activities in a science laboratory. Students are trained to follow all rules and regulations outlined in the performance of laboratory activities. Teachers also need to prepare themselves with manipulative skills so as to guide students to master the skills. Lewthwaite (2014) who studied the views of teachers on laboratory work, explains the various benefits derived from laboratory work. There are several laboratory activities such as demonstrations, experiments and inquiry investigation. With demonstration activities, teachers can demonstrate manipulative skills and actual procedural students. In spite of that, the development of skills might be inhibited because students tend to be observers rather than be actively and directly involved.

For other laboratory activities such as experiment and inquiry learning, can help the development of manipulative skills for students to directly control apparatus and chemicals. This can make students focus on the operation of experiment and complete the requested task. Added value is given for

investigative activities such as a more authentic inquiry and offer extra skills in experimenting because students are actively involved in investigative activities. According to Fadzil & Saat (2014), manipulative experience as 'hands-on' is the key to the relationship between scientific skills in science education. The ability of students to integrate between theoretical learning (cognitive domain) with laboratory activities (psychomotor domain) is required to master the scientific skills.

2.1.3 Correlation between Manipulative Skills and Science Process Skills

Science curriculum in Malaysia is strategically arranged so that two elements of scientific skills and positive attributes can be integrated in the classroom. The elements to optimize the learning outcomes of effective science learning is scientific skills. Scientific skills encompass of science process skills and manipulative skills. Both of these skills have a very close relationship and lean on each other. Science process skills is a process that involves the cognitive domain to stimulate creative and critical thinking. Similarly manipulative skills is a process that involves the psychomotor domain to promote the use of such physical control of apparatus and chemicals in the laboratory.

In carrying out the practical work, both the scientific skills of science process skills and manipulative skills cannot be left 'stand-alone' as a very close relationship and can be assessed together as happened in PEKA (Penilaian Kerja Amali) started in 2009. The science process skills help in building conceptual understanding of science, while manipulative skills stimulating observations, making predictions and inferences.

For years, Malaysian Examination Syndicate (LPM) has prepared reports for the analysis of Sijil Pelajaran Malaysia (SPM) of previous examination revealed on how candidates answered the examination paper. In the report known as Kupasan Mutu Jawapan, LPM recommend to the future SPM candidates to master the basic concept of Chemistry to achieve the objectives of subjects and assessment of Chemistry. Candidates are also advised to engage in carrying out experiments in school lab so that manipulative skills can be improved. Therefore, teachers need to provide opportunities for every student to perform laboratory work, not only act as spectators like demonstrations as well as to emphasize the scientific method and science process skills while conducting experiments. The diversity of methods and approaches of teaching and learning for chemistry teachers also suggested by the LPM to improve teachers' science process skills and manipulative skills in addition to help the country's public examination.

2.2 Inquiry Based Science Education

Various approaches and learning strategies implemented by educators in order to achieve meaningful learning in laboratories. Among that, one of the most significant in science learning is Inquiry-Based Science Education (IBSE). Demeo, (2005) discusses in his study; inquiry learning relevance and related to the manipulative skills in the teaching laboratory. Generally, he stressed that the paradigm of inquiry learning in the laboratory can give educators an alternative approach that gives more 'power' and the involvement of the students.

Inquiry-based science learning is an approach that builds student-centered learning environment that helps stimulate the cognitive, psychomotor and affective individuals. There is an opinion stating inquiry-based science teaching is effective to develop the skills of arguing (Wilson, Taylor, Kowalski, & Carlson, 2010). This refers to the skill of asking questions and answering questions. Practical work

emphasizes learning through inquiry approach in which students are encouraged to learn through discovery of the phenomena that occur in the environment in order to facilitate the understanding and knowledge of scientific theories (Fadzil & Saat, 2014).

The term 'inquiry' generally signifies a process of information resulting from the activities of the investigation, which stems from the intuition to know that raised questions in order to dismantle a question (Shamsudin, Abdullah, & Yaamat, 2013). In the laboratory school, students have the opportunity to ask questions, investigate, propose ideas and justify explanations based on data collected (Vhurumuku, 2011). When the inquiry process occur, aspects which are also involved is the science process skills and manipulative skills such as observing, measuring the number and space, as well as the experimenting (Nik Kar & Saleh, 2012).

In general science curriculum, teaching and learning process should be based on learning through one's own experience that emphasizes student inquiry approach. This is consistent with the goal of studying chemistry in particular, to produce students who have the knowledge and skills in chemistry and the ability to apply knowledge in line with the attitudes and values to resolve problems in daily life.

2.3 The Use of Inquiry Based Learning Module in Laboratory

Laboratory work is a core component of chemistry in high school or at the university level in the world. Unfortunately, research in science education shows that conventional laboratory activities often fail to engage students exclusively in the discussion and analysis of a scientific concept. The result will inhibit the development of inquiry skills (Xu & Talanquer, 2013). Among the criticisms emanating from conventional laboratory activities is the laboratory assignments or instructions in the form of 'recipes' or 'cookbook' that only allow students to 'obey' in accordance with the instructions of teachers (Abraham & Millar, 2008; Laredo, 2013). Assignments and directions are shaped like this only serves to confirm the idea or concept of a specific concept (Hofstein & Kind, 2012), in contrast to investigatory activities with the inquiry approach that acts as a guide to explore a phenomenon.

Although it is important in science for students to learn how to obey the instructions and procedures, but to give one hundred percent dependency on manual cookbook labs will limiting the intellectual students (Platova & Walpuski, 2013). Thus improvements in teaching laboratories such as the use of learning module that integrate inquiry approach can be an important step to help students promote higher order thinking skills while reinforcing the manipulative skills.

The use of learning modules is challenging for teachers to be more creative when developing a module. The modules built need to be consistent and in accordance with the curriculum to be taught. There are a variety of modules built by teachers and researchers, such as web-based modules, simulation-based modules or text printed modules most commonly found in schools. The use of modules is different from teaching using textbooks that are more traditional and conventional. The modular approach is more creative approach, encouraging a deep and meaningful learning and lead to critical thinking.

Johnstone & El-Banna (1986) found that students able to process information with the characteristics of a laboratory manual such as the use of a simple and precise language, experimental procedure in the order and there are drawing or

diagram of apparatus and materials needed. In order to provide data that may be useful in the design of improved laboratory manual, this study examines the role that inquiry based learning module help in facilitating the processing of information in the laboratory to help the enhancement of manipulative skills.

7.0 Conclusion

Most studies on laboratory learning tend to see relationships between learning experience in a laboratory with a scientific concept. In other words, cognitive and affective domain often become the focus of the study. Psychomotor aspects of learning laboratories received less attention (Hofstein & Lunetta, 2004) although manipulative skills are important objectives in the learning lab. Further research on learning laboratory in the psychomotor domain can reveal the relationship and influence between manipulative skills with other skills in cognitive or affective domain.

Research studies on the effectiveness of the use of learning modules to help improve manipulative skills have not yet been reported. This study examines the design of learning modules that use diagrams and charts are integrated with the text and also applying inquiry-based learning to improve manipulative skills more efficiently and better. In other words, this study can be expected to show students using inquiry-based learning modules will achieve higher score in the performance of manipulative skills than students who did not use the module.

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