

Enhancing Scientific Literacy through Implementation of Inquiry-Based Science Education (IBSE) in Malaysia Science Curriculum

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Abstract

This paper reviews on the development of Inquiry-based Science Education (IBSE) as the element of scientific literacy from the perspective of Malaysia context. Based on the findings in previous studies it can be concluded that scientific literacy has become one of the skills that required in the 21st-century education. This article focuses on the current scenario of the development of inquiry-based education issues at the global level and focusing on the science education context in Malaysia.

Keywords: Inquiry-Based Science Education, Science Education, Science Curriculum

Introduction

The term of scientific literacy nowadays become a dominant educational slogan and place as a major goal for science education over the past two decades in many countries (Millar, 2006). In addition, teachers as educators become the important factor in developing and promoting scientific literacy among students. Generally, to be a scientifically literate person, teachers must be well-prepared with the skills of inquiry as inquiry becomes the "heart" of science education. This approach involves the exploration process to create problems, make discoveries, and to investigate the discovery to gain a new knowledge. Teachers should have a firm understanding of scientific inquiry and be abreast of the current pedagogical advances affecting students learning. In Malaysia, Ministry of Education (MOE) have been introduced six student aspirations through National Education Philosophy's vision. It consisted of Knowledge, Thinking skills, Leadership skills, Bilingual Proficiency, Ethics and Spirituality and National Identity. Thinking skills become one of the very important key elements to enhance inquiry skills that emphasize 21st-century skills. A review of the findings of previous studies on the scientific inquiry skills among science teachers in Malaysia and their understanding of the elements are seen as playing an important role in student achievement in science. Furthermore, changes that happens at the global level had produced effects and challenges against the national education plans (UNESCO, 2015). Similarly, Malaysia educational system is about to make great changes toward the 21st-century education. As refers to a statement in the New Economic Country Model (National Economic Advisory Council (NEAC), 2010), science education needs to give emphasis on the development of the human capital as it becomes the most important element

in many countries because it was giving contribution from development aspect of science and technology policy. Regarding this issue, teachers' role become important in promoting science literacy through inquiry-based in schools and also in a society.

Inquiry-Based Science Education (IBSE)

Inquiry-based science education (IBSE) is considered to be an important current trend in science education reform which is based on the belief that it is important to ensure that students deeply understand what they are learning, and not simply repeat contents and gather information from teachers. IBSE can be defined as activities through interaction of teachers and students which connects the two activities of teaching and learning. In the 1990s, many science education reforms around the world put much emphasis on the importance of students' knowledge of scientific inquiry methods. Furthermore, basic understanding of science and skills are also needed for making informed decisions about scientific issues that affecting their lives (National Research Council [NRC], 1996). According to The National Science Education Standards (NSES p. 23), scientific inquiry defines as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work.

The philosophy of inquiry based learning finds its antecedents in constructivist learning theories, such as the work of Piaget, Dewey, Vygotsky, and Freire among others and can be considered a constructivist philosophy. Based on NRC (2000), inquiry involves observation, questioning, investigation, analysis of data, and predictions regarding the results. Basically, IBSE is important for an in-depth understanding of science content which is not only a way to teach science effectively but more importantly it can be a way to teach students how to learn in a broader sense, developing problem-solving comprehension and critical thinking skills, using properly prior knowledge and rejecting naïve conceptions (Agrusti.G ,2013). In inquiry-based science teaching, students are expected to engage in the practice of constructing scientific knowledge rather than rote memorization of science concepts. IBSE may also include different degrees of inquiry learning depending on the teaching competencies of the teachers on the inquiry skills. Similarly, some developing countries such as Lebanon (National Center for Educational Research and Development, 1997), and Israel (Tomorrow98, 1992), Zambia (Curriculum Development Center [CDC], 2000; Ministry of Education [MOE], 1996) also being adopted IBSE in their country.

Inquiry-based learning encompasses a variety of approaches to teaching and learning, including activities like investigations, projects, field work, case studies, individual and group research projects. The learning process which engages students in inquiry-based learning, including (a) asking themselves. (b) obtaining supporting evidence to answer questions. (c) explain the evidence collected. (d) associating information with the knowledge gained from process investigations. (e) establish an argument and justification for an explanation. According to Carin & Sund (1980), inquiry is defines as indirect learning which involving exploration and discovery activities related to the process of obtaining an information. It is based on questioning and problem-solving in the teaching and learning activities. This indicates that the inquiry is centered on students rather than teachers, but teachers only act as guides to give

students the opportunity to discover the real information. According to Giliberti(2012), IBSE insists on the appropriation of knowledge through individual investigation and questioning attitude leading the pupils to learn by experimenting in partnership with the teacher. Furthermore, learning by doing is based on a personal investigation that helps students to develop their cognitive processes as well as the sense of curiosity and creativity.

One of the international assessment that measures students' scientific literacy Malaysia is PISA (Programme International Students Assessment). The Blueprint concluded from the results of PISA and TIMSS that Malaysia students did not perform well with regards to cognitive skills such as knowledge recall, ability in reasoning and the application of knowledge in problems solving. Scientific literacy which measured in PISA is not only gauged the level of understanding of science alone, but also an understanding of the various aspects of the process of science, as well as the ability to apply knowledge and science process in real situations faced by students, whether as an individual, community or international (OECD 2006).

In Malaysia context, the science and mathematics achievement still ranked below the OECD average mean score. Regarding the latest statistics on mean score in PISA 2012, Malaysia only had 420 points in Science, which ranked below the OECD average mean score (501), and ranked 52th, out of 65 countries. TIMSS is an another international assessment shows a similar result. TIMSS assessment is based on content and cognitive skills of Mathematics and Science curricula of schools, namely the thinking processes of knowing, applying and reasoning. Malaysia's performance in TIMSS indicates that student performance has fallen from 1999 to 2011. Regarding TIMSS 2011 analysis, only 47% of the Malaysian students were involved in science investigation which less than half of the lessons (OECD 2012). This scenario remarks our future teachers as needed to be changed to be critical and creative thinkers. They are should be able to find solution and create innovations and services as a teacher. Therefore, the key criteria in nurturing these individuals are curiosity, inquisitiveness and through inquiry.

According to the Framework of PISA 2015, PISA consists of four domains that enable the assessment of scientific literacy, consists of the domain context, competency, knowledge, and attitude. Description of measurement for each domain was shown in Figure 1. Basically, the domain of competency measured by PISA framework combined both scientific knowledge and attitudes of individuals which required skills of inquiry which are a very important element in developing thinking skills and science process skills.

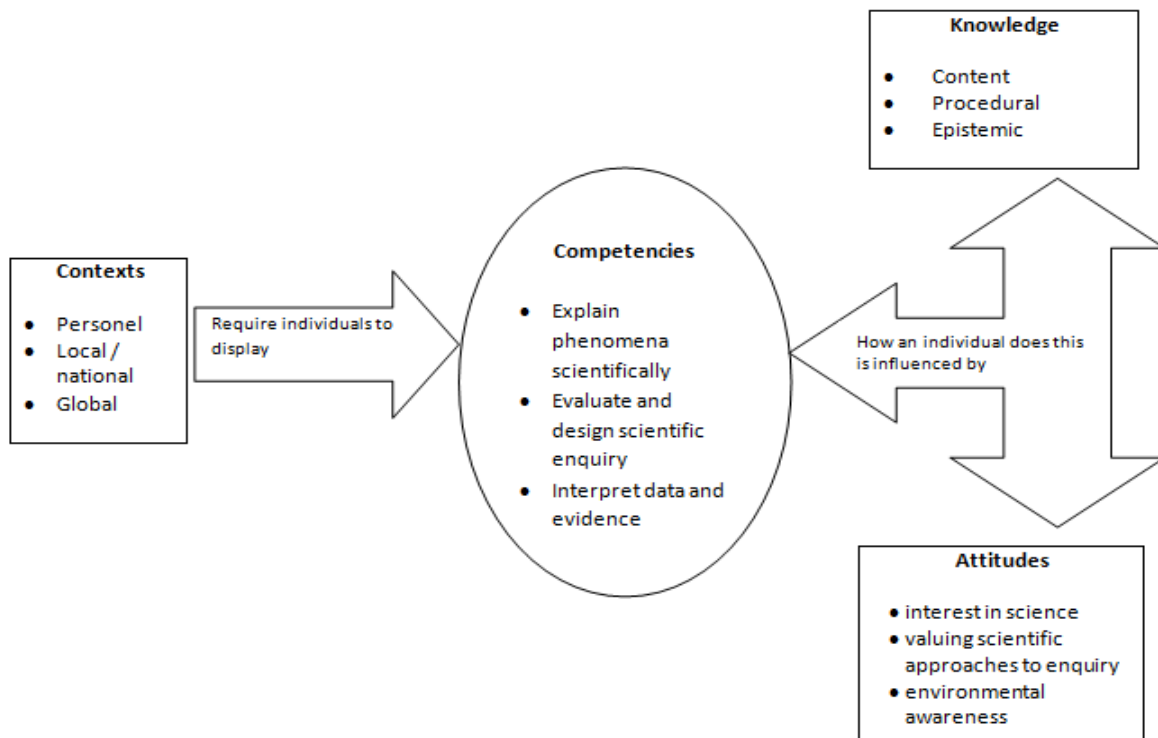


Figure 1. Framework for PISA 2015 Scientific Literacy Assessment
 Source: Adapted from PISA Framework 2015 (OECD, 2015)

Discussion

In Malaysia curriculum context, science is view as a meaningful and useful subject for creating the students as an inquirer. Teacher role as a leader of inquiry who imparts the excitement and value of science in a science lesson. Basically, inquiry enable students to ask questions, develop scientific principles, formulate predictions, collect and analyze data, describe objects, make observations, synthesize laws, construct explanation against current scientific knowledge and communicate their ideas to others (Wenning, 2007). Based on the international achievements, it can be clearly proven that the inquiry skills in Malaysia science education still lacking. An individual is not able to carry out an investigation without practicing or mastering such inquiry skills. Therefore the inquiry level has to be developed from basic inquiry (structured inquiry) into open inquiry. According to National Research Council (NRC) (2000), the inquiry can be divided into three levels consist of structured inquiry, guided inquiry, and open inquiry. While, H. Banchi and R. Bell (2008) define according to experience how much guidance (about procedure and expected results or guiding questions) is provided to students by teachers four levels of inquiry which are confirmation, structured, guided and open inquiry. These four levels of inquiry that being adopted in the science curriculum needed to be focused more on the students' level development. Curriculum Development Centre benchmarked the Malaysia Curriculum based on the TIMSS Framework and PISA Framework by the OECD Programme for International Student Assessment.

Malaysia has long history with inquiry in education system which has been introduced Inquiry-based Science Education (IBSE) in the science curriculum since the 1960s with introducing scientific activities by conducting experiments. In the 1960s to 1980s science subjects have been introduced as a separate subject in primary schools. Next, in 1983 onwards (KBSR), Science infused with Geography subject and known as History & Civic (Man and his Environment). In 1992 science was known as a separate subject again. To develop deeper insights into the practice of inquiry-based science education (IBSE) as an innovative approach to teaching science, science inquiry programs in Teachers Training Institutes and Universities has been implemented. Starting in 2017, the Secondary School Curriculum Standard (KSSM) is carried out to improve the Secondary School Integrated Curriculum (KBSM) which was implemented in 1989. KSSM formulated to meet the needs of new policies under the Malaysian Education Blueprint (2013-2025), to enhance the quality of curriculum implemented in secondary schools by comparing with international standards. According to Lee (1992), Malaysian science educators recognize the need for the science curriculum to keep in line with the international trends which shifted the vision and emphasize the focus in the curriculum from knowledge to inquiry learning. KSSR and KSSM as the new curriculum documents have been emphasized with inquiry approach. Based on the report from Educational Planning and Research Division (Ministry of Education, Malaysia, 1997), Malaysian teachers were unable to implement the inquiry-based curriculum effectively because of lacked the necessary science background knowledge and understanding of the content of the curriculum.

For the successful implementation of KSSM , teaching and learning of teachers need to emphasize Higher Order Thinking Skills (HOTS) which focusing on inquiry-based learning approach and project-based learning, so that students can master the skills required in the 21st century education. Secondary Schools Curriculum Standards (KSSM) aims to instill and develop the creativity of students through experience and investigation for gain the knowledge and skills of science and technology and also scientific attitudes and values. Teaching and learning science approaches emphasize into the in-depth study by using the inquiry method. Inquiry is founded on three integral domains which consisted of; (i) knowledge, understanding and application, (ii) skills and processes and (iii) ethics and attitudes. By master of these skills, students enables to solve problems and make decisions in their everyday life. In general, the Malaysian primary and secondary science and mathematics curriculum contain a very good proportion of higher order thinking skills (HOTS). Using the inquiry approach through activities such as project-based learning, problem-based learning and STEM approach towards problem-solving and decision making will develop students' higher order thinking skills (HOTS). This is because HOTS applied in teaching and learning while performing in-depth learning.

Analysis from the two international assessment (TIMSS and PISA) gave the skewed perception of scientific literacy level among Malaysian students which is affected by the failures execution of science teaching from the teachers. Based on the analysis from TIMSS 2007 and 2011, Malaysian students not regularly conduct experiments. Learning science requires high

scientific skills that can only be obtained through experiment or experience while conducting the investigation. Unfortunately, today's scenario of science curriculum in Malaysia unable to provide wide opportunities for students to develop their inquiry skills. The excellent curriculum contents are not the only materials that can provide scientific skills and develop scientific literacy among students. Teachers as educators should know their role on how to deliver their knowledge through inquiry skills. Research on teachers' knowledge shows that both teachers' subject knowledge and pedagogical knowledge are crucial to good science teaching and student understanding (Shulman, 1987). According to McFarlane (2013) requirement for the teaching definitely encouraged your efforts about understanding the knowledge and skill that teachers needed for involving the students in learning science effectively. The science teachers or educators needed to understand the rationale of teaching using inquiry in developing scientific literacy and to encourage new paradigm of the class without borders which are known as the global environment. The process of science teaching requires scientific literacy to produce a higher level of understanding among students. To be scientifically literate person, teachers needed to understand inquiry skills as the basic of science education. Implementation of inquiry can be difficult as the vast majority of teachers have been taught themselves through more traditional direct transmission approaches and hence, may find it difficult to convert to a teaching approach they would never have used nor experienced before (Barron et al,2012).

Based on Pathway to Inquiry or PTI project which funded by the National Science Foundation (NSF) in 2006 until 2009, inquiry skills are basic scientific skills including asking testable questions, generating hypothesis, designing investigations, collecting and analyzing data, interpreting the results, and drawing conclusions (Lou, Y., Blanchard, P. & Carnaggio, J.,2009). This pathway is about guidelines for teaching students on how scientists ask and find answers to questions. This project also offers two interrelated tools known as Inquiry Skill Analyzer (iSA) and an Inquiry Activity Portal (iAP). The iSA is based on the seven areas of science inquiry and their underlying skills as outlined in the National Science Education Standards (NSES) while the iAP is designed to assist teachers in selecting inquiry activities in their lesson.

In order to produce science teachers who mastery in inquiry skills, these skills should be learned deeply while preparing them in teacher training institutions. Findings of previous research showed that the future teachers needed to understand about scientific inquiry elements to make sure the process of instruction and science learning become more meaningful to the students. The holistic learning focused more on the inquiry-based education which teachers provide experience to students through inquiry activities such as research-based activity and problem-based activity. Unfortunately, student interest in STEM education in many countries like United States, Malaysia, and Indonesia experiencing reduction, while those countries industrial need about STEM had increased (Syukri, Meeran, & Halim, 1990). According to Norjoharudeen (1996), exam oriented in the Malaysia education system does not provide the conducive environment toward connectivity into science literacy.

As many reported, the emphasis is given to pass in exams and during answering questions in teaching and science learning. Therefore, the inquiry skills are not well developed

during the science lesson. Findings also show evidence that most science teaching methods are to transfer the facts without trying to practice through inquiry and other approaches instruction that involved students actively. Various teaching methods were able to foster the students' interest to learn science (Chiappetta, Koballa & Colette, 1998). Although the written curriculum developed by the Ministry of Education (MOE) specifically states that science education consists of three main components which are knowledge, scientific skills, and scientific attitudes which provide the important elements of inquiry, there is still a gap between the aspired curriculum, implemented curriculum and examined curriculum. By possessing positive scientific inquiry, the Malaysian students will have strong inclination towards science. Furthermore, as a developing countries, Malaysia needs to have students who have high skills of inquiry such as problem-solving skills, able to interpret the scientific knowledge and methods into their daily life and hence being able to actively participate and contribute to the future Malaysia society.

Conclusion

From the perspectives of science education in Malaysia, inquiry skills become very important elements in the science classroom. By mastering the inquiry skills, students will be encouraged to develop their scientific literacy. As a way to enhance the skills of inquiry, science teachers should given exposed on how to teach and conduct inquiry learning effectively. According to TIMSS and PISA assessments, there is a gap between the achievement level of Malaysian students in terms of scientific literacy level. The implementation of IBSE in school is an important challenge for the future of our schools, and it is a long-term goal. Malaysia itself is moving towards the transformation of science education through the Secondary School Standard Curriculum which been proposed by Ministry of Education (MOE). Based on the curriculum document, inquiry forms the basis of science education in the acquisition of knowledge, skills and attitudes. The inquiry is essential for science lesson where the shift from traditional 'cookbook' teaching to inquiry-based pedagogy is needed.

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