Pertanika J. Soc. Sci. & Hum. 25 (S): 51 - 72 (2017)

PERTANIKA JOURNALS

SOCIAL SCIENCES & HUMANITIES

Journal homepage: http://www.pertanika.upm.edu.my/

Practices of Inquiry-based Science Education: Case Study of Thailand's Junior High School

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ABSTRACT

Inquiry-based science education (IBSE) has become a prominent approach in science educational reform in all countries. This research is a case study to analyse the practices of IBSE in the science class of one Junior High School in Chiang Rai, Thailand, as part of the overseas teaching practicum project conducted by SEAMEO. Respondents were two Filipino teachers of the English Programme Class, and have worked for three years. Adaptation of IBSE in the curriculum was captured by analysing the Thai's science curriculum. The concepts of IBSE were analysed in the teachers' syllabus and lesson plans. A series of classroom observation was also done to check the real practices of IBSE, while all activities were noted and recorded. Additional information on teachers' perspectives on IBSE had been obtained through structured interviews. Analysis was based on the Tafoya's concept of inquiry levels to examine the type of inquiry. The research confirmed that the concept of IBSE has been written in the lower secondary science curriculum in Thailand. Both teachers have shown relatively good perspectives on science and IBSE, and commonly applied the structured inquiry, in which teachers still dominate the learning process, but students have also been involved.

Keywords: Inquiry-based science, junior high school, Thailand

ARTICLE INFO

Article history:
Received: 01 December 2016
Accepted: 23 August 2017

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ISSN: 0128-7702

INTRODUCTION

Teaching meaningful science is a real challenge for secondary teachers in many countries. Designing an innovative science class will not be possible if the teacher, as the architecture of instructional design, does not have adequate knowledge and skills of the science curriculum and pedagogical

strategy. As proposed by Shulman (1987) in his paper, teachers should acquire a basis of knowledge for teaching, i.e. aggregation of knowledge, understanding, skills, and technology, of ethics and disposition, of collective responsibility, as well as a means for representing and communicating it.

To improve the quality of lesson planning, routinely the teacher will break down the national curriculum into practical lesson plans in detail by working individually or in a team of teachers. Teachers are required to consider the principles of teaching and learning science, such as it should be an active, innovative, creative, effective, and meaningful learning process. Science learning is expected to change students' mindset and attitudes, develop thinking skills, promote scientific behaviour, and provide an opportunity for them to achieve the best learning outcomes that match the targeted competencies.

However, the quality of science education also depends on students' perceptions, behaviour, and attitudes relating to science. Students, according to the research carried out by Meyer and Crawford (2015), assume that science is as a way to find out about things, reading a book, making progress, as well as doing experiments and quizzes. Following their participation in scientific activities, students are able to enhance their understanding of the scientific processes and of the active role of the scientist in observing, analysing, and making inferences. In fact, science is not only a subject at school, but it also includes various activities for changing views of what scientists do, and the demystification of the actual process of becoming a scientist.

In the current progress, following the concept of STEM education, science is taught as an integrated course, in which technology, Mathematics, language, and other subjects are set integrative to be studied under specific themes. The integration of science with other subjects is a method that can create meaningful learning, enrich students' learning experiences, deepen their understanding, as well as change their attitudes and soft competencies about science facts by identifying and applying a method which can appropriately be integrated with the teaching and learning process (Berlin & Lee, 2005; Nikolova & Stefanova, 2014).

School science could be considered in the views of: (1) scientific process, which is systematic, empiric, and logical; (2) tentative scientific product; (3) scientific behaviour such as being open-minded, curious, sensitive to the environment, responsible, cooperative, creative, and innovative; and (4) application of the technology, values of scientific knowledge and the existence of human beings as the users of technology (Lukum, 2013).

Science Education in Thailand

The way in which science achievement can be improved in order to nurture students' science literacy is a current challenge for all countries. The level of science literacy is argued to be parallel with the advance progress of the economy and technology of the country, as many scholars cite the

PISA (Program for International Student Assessment) result as the prime metric to categorise countries' statuses comparatively. Some Asian countries (Singapore, Japan, Taiwan, China, Vietnam, Hong Kong, and Korea) are occupying the top ranks in the attainment of science literacy, which makes them the benchmark for others in science education. Those countries spend a lot of budget to promote science education, and reform science schools to be more inquiry-based (Koh & Lee, 2007; Ogura, 2013; Rahim, 2013).

There are four South East Asian countries assessed in PISA; two countries (Singapore and Vietnam) ranked in the top of PISA league and two others (Thailand and Indonesia) in the low ranks. Thailand ranked the 54th among 72 countries, according to PISA 2015, and Thai students scored 421 in science literacy, which is higher than Indonesian students who scored 403.

Science is one of the main subjects in Thailand (EP-Nuffic, 2015). Science education in this country aims to enhance students' desire to search for knowledge, enhance their interest and capability in science, and ensure that students are able to learn at any time and any place continually throughout their lives (Office of the National Education Commission & Office of the Prime Minister Thailand, 2003). Science education in Thailand emphasises scientific knowledge, nature of science, and relationship between science, technology and society.

According to Sothayapetch (2013), the promotion of science education in Thailand seems to be progressively developed. Thai science education emphasises procedural knowledge or scientific processes, and the science curriculum is relatively similar to the PISA framework. Sothayapetch also stated that Thai teachers conducted more experiments in the school laboratory. It can be assumed that inquiry-based learning has become one of the prominent approaches to learn science in Thai classrooms.

Understanding Inquiry-based Science Education

The idea of inquiry-based science education (IBSE) was introduced and developed a long time ago, and it is widely adopted in the science curriculum of most of the countries. The concept was originally developed from the idea of John Dewey, in which he stated that science should be set as the subject matter and as method as well (Dewey, 1964). In other words, it can both be a pedagogic strategy for teaching science and learning content as well (Abd-El-Khalick, Lederman, Mamlok-Naaman, & Hofstein, 2004). Furthermore, Heinz and her colleagues highlighted the science inquiry as three different ideas in education: (1) a set of skills to be learned by the students; (2) a cognitive understanding of the processes of inquiry such as the logic of a controlled experiment; and (3) a pedagogical strategy (Furtak, Seidel, Iverson, & Briggs, 2012).

The definition of IBSE has been progressively formulated and associated with the goal and the needs of science learning, but it tends to be associated with a series of similar steps which actually

reflect the scientific method that is usually practised by the scientist. The general steps of inquiry consist of identifying problems, posing research questions, reviewing literature, generating hypotheses, planning investigations, experimenting, collecting data and information, constructing models, communicating the results, and forming coherent arguments (Linn, Davis, & Bell, 2004; Rundgren, 2017).

The National Research Council in the USA defines scientific inquiry in the National Science Education Standards (National Research Council, 1996) as learning science that follows the method used by scientists in studying natural phenomena and suggests an explanation based on evidence obtained through the investigation. The inquiry also leads students in increasing knowledge and understanding of science, as scientists can study and understand natural phenomena.

In the inquiry-based learning, students learn how to pose questions, conduct investigations and collect evidence, develop explanations based on the data obtained, as well as communicate and maintain their conclusion (National Science Teachers Association, 2003). Scientific inquiry is a powerful way of understanding science contents (Wenning, 2011). Inquiry enables students to ask questions, formulate predictions, make observations, describe objects, collect and analyse data, develop scientific principles, synthesise laws, construct explanations, and communicate their ideas to others in the science learning (Tze-Jiun & Nurzatulshima, 2014).

Level of Inquiry

How to apply inquiry-based learning in science classrooms had been discussed years ago by Tafoya, Sunal, and Knecht (1980) who divided inquiry into four levels: confirmation inquiry (level 1), structured inquiry (level 2), guided inquiry (level 3), and open inquiry (level 4). Those levels are distinguished based on the responsibility of teachers and students to do activities in three main stages of stating or identifying the problem, selecting the procedure, and formulating the solution (Table 1).

Table 1
Level of inquiry based on student-teacher responsibility

Level of inquiry	Problem	Procedure	Solution
Confirmation/Verification	Teacher	Teacher	Teacher
Structured inquiry	Teacher	Teacher	Student
Guided inquiry	Teacher	Student	Student
Open inquiry	Student	Student	Student

Tafoya's idea was explained further by some scholars, such as in the work of Zion, Cohen, and Amir (2007). They elaborated *structured inquiry*, as research problems, questions, hypotheses and complete instructions at each stage of procedures are readily stated by a book's instructions or the teacher. Students need to execute the working plan, gather data, analyse, and make a conclusion. Then, *guided inquiry* as the teacher comes with problems and students determine the process and solutions to solve the given problems. Students are able to construct new knowledge in the inquiry process and gain their understanding and transferable skills. Students can use their developing knowledge and conceptual understanding to dig more deeply into the key ideas of science. The last is *open inquiry*, in which the teacher defines the knowledge framework and lets the students define questions, problems, or hypotheses, design their own experiments or investigations, analyse and communicate their learning (Zion & Mendelovici, 2012; Zion, Cohen, & Amir, 2007).

Wenning (2007, 2011) offered more complex levels/stages of inquiry, where they divided inquiry-oriented teaching approaches into six levels considering students and teacher authorities, i.e. discovery learning, interactive demonstration, inquiry lesson, inquiry laboratory, real-world application, and hypothetical inquiry (Wenning & Khan, 2011).

According to Rundgren (2017), who analysed the implementation of IBSE in European countries, the rise of science and science education is a global culture. He argued that there are cultural differences in science education in different countries. It can be argued that science concepts will remain the same all around the world, but the practices of science education will not be the same. Local variation and differences regarding foci and applications of science in different cultures must be respected. Cultural differences in how science education is conducted does not only relate to superficial features, but is related to the very heart of what science education means among teachers and also educational practices.

We did a case study to analyse the practices of IBSE in one lower secondary school in Thailand to answer the following questions: What is the concept of IBSE in the lower secondary science curriculum in Thailand? What are the perspectives of teachers on science? What are the practices of IBSE in the science classroom? What kind of assessment is done to measure students' learning outcomes?

METHODS

This research is a case study carried out on July 21st to August 10th 2016 at Chiang Rai Municipality School 6, located in Rimkok District, Muang District, Chiang Rai Province, Thailand, during the South-East Asia (SEA) Teacher Project organised by SEAMEO. There are two optional courses in this school, i.e. Science-Mathematics (SM) and English Programme (EP) (Figure 1). EP is a programme with foreign teachers, and English is the language of instruction.

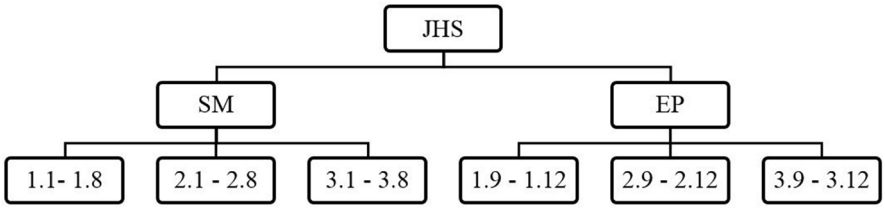


Figure 1. Distribution of two programmes at Junior High School

Two teachers are assigned for each course: a main teacher, and an assistant teacher called a Learning Support Assistant (LSA). The main teacher is responsible for preparing the lesson plans, delivers and transfers the content knowledge, nurtures the skills needed, and conducts assessment. Meanwhile, the task of the LSA is to assist the main teacher by taking care of the students, collecting students' phones before learning activities, doing administrative jobs, managing the students' schedule, helping the foreign teacher to control and manage the class during the learning activities, and helping the foreign teacher to translate some teaching materials if there are some difficulties in understanding the concepts taught.

Our research focused on EP classes. Two teachers from the Philippines were purposively selected as the respondents. One has a bachelor degree in Physics education (Teacher A, female, 30 years old), and the other graduated with a bachelor degree in Health education (Teacher B, male, 28 years old). Both have worked for three years with 20 hours per weeks in this school. The experiences of both teachers would relatively be similar as they are assigned as foreign teachers in the same EP classes and have to make use of the same curriculum.

We carried out document analysis of the science curriculum, syllabus, lesson plan, and assessment sheet to get data on how the IBSE concepts are adopted in Thailand's science curriculum, syllabus, and teachers' lesson plans. A structured interview was done with the teachers to capture their perspectives on and practices of science learning they carried out in their classes. In the personal interview, we applied two methods; for teacher B, we read the list questions to him in a face-to-face setting and recorded his answers. In case of teacher A, due to certain inconveniences, we were not able to do a face-to-face interview, hence she wrote the answers and sent us back by email. To analyse the results of the interview, we stressed on certain terms used by teachers which represent the concept of science, science teaching and learning, and the IBSE.

Table 2
List of class observations

Meeting	Class	Number of Students	Topic	Teacher
1st meeting	M 3.12	29	Energy	Teacher A
2nd meeting	M 1.9	34	Mixtures	Teacher B
3rd meeting	M 1.12	30	Mid-term Test	-
4th meeting	M 1.9	34	Solutions	Teacher B
5th meeting	M 1.11	33	Solutions	Teacher B
6th meeting	M 2.11	39	Earth	Teacher A
7th meeting	M 2.10	37	Earth	Teacher B
8th meeting	M 1.10	35	Solution	Teacher B
9th meeting	M 2.12	30	Soils	Teacher A

Science learning processes were observed during nine meetings so as to gain information on the real practices of science learning delivered by both teachers (Table 2). Moreover, field notes enriched with visual recording were taken during the learning process in all the observations. All data were analysed accordingly, and then the existence of IBSE principles and type of inquiry applied in the classroom were also checked. Students' learning outcomes were analysed based on the products of students' projects and the assessment.

RESULTS AND DISCUSSION

Analysis of Science Curriculum of Thailand

The Basic Education Core Curriculum 2008 is the current curriculum applied in all Thai schools. Science is one of the main subjects offered from primary level. It generally covers knowledge, scientific processes, thinking skills, and scientific attitudes. Science will enable students to learn with an emphasis on linking knowledge with processes, acquiring essential skills for investigation, building knowledge through investigative processes, seeking knowledge and solving various problems based on diverse data and evidence (Table 3).

Table 3
Thailand's lower secondary science curriculum

Item	Description	Grade
Coverage of Science	Application of knowledge and scientific process for study and search for knowledge and systematic problem-solving; logical, analytical, and constructive thinking, and scientific mindedness	
Learning Area	Strand 1. Living Things and Processes of Life	
	Sc1.1. Living and Family	7, 8
	Sc1.2. Process and Genetic Transmission	9
	Strand 2. Life and the Environment	
	Sc2.1. Local Ecosystem, Living things in ecosystem	9
	Sc2.2. Natural resources and sustainability	9
	Strand 3. Substances and Properties of Substances	
	Sc3.1. Properties of Substances	7, 8
	Sc3.2. Principles and nature of change of substances	7, 8
	Strand 4. Forces and Motion	
	Sc4.1. Electromagnetic, gravitational and nuclear forces	7, 8, 9
	Sc4.2. Types of motion of natural object	9
	Strand 5. Energy	
	Sc5.1. Energy and Life	7, 8, 9
	Strand 6. Change Process of the Earth	
	Sc6.1. Process in the earth surfaces	7, 8
	Strand 7. Astronomy and Space	
	Sc7.1. Evolution of the solar system, galaxies and the universe	9
	Sc7.2. Space technology	9
	Strand 8. Nature of Science and Technology	
	Sc8.1. Relation between Science, Technology and environment	7, 8, 9

The main strands of the science curriculum in Thailand are: 1) living organisms and the process of life; 2) life and environment; 3) substances and the properties of substances; 4) force and motion; 5) energy; 6) earth changing processes; 7) astronomy and outer space; and 8) natural science and technology (Table 3). Each strand consists of one or two standards to be achieved at the end of learning process. Strand 2 (Life and Environment) and Strand 7 (Astronomy and Space) are only taught in Grade 9. Some strands are learned in Grades 7 and 8. Low secondary science is taught twice a week, each in 120 minutes, which is 40 minutes per hour.

The structure of the science curriculum in Thailand is unique as the strands or topics are constantly on the same themes from primary to secondary. The differences are found in the depth of the content, the psychomotor skills to be developed, and the behaviours and attitudes to be nurtured. However, the attitudes or behaviours that should be nurtured are relatively similar from primary to secondary.

Primary school science puts the stress on how to stimulate the curiosity of young children about science phenomena surrounding them. Students will learn about general concepts, facts, and characteristics of living things, substances and materials, simple forces and motion, and physical performances of earth, by posing questions which will express students' curiosity and interest. Students also do observation, exploring, communicating, writing and drawing the objects (Figure 2).

Domain	Intended Learning
Grade 3	
Cognitive Understand	*general characteristics* of living things and the *existence of diverse living things in the local environment* ; the *phenomena and changes in materials in the surroundings* ; natural forces; forms of energy; *physical properties of soil, rock, water, air, the sun and stars* ;
Psychomotor	
Posing questions	living things, materials and objects as well as various phenomena in the surroundings.
Observing, exploring, verifying	observe, explore and verify with the use of simple instruments
Communicating	communicate what has been learned through story-telling
Writing and drawing	writing or drawing pictures
Applying	scientific knowledge and processes in life and search for additional knowledge;
Implementing	implement the projects or work assignments as prescribed or in accord with their interests
Attitudes	
Enthusiasm, interest, kindness, care, concern	show enthusiasm, interest in learning and appreciation of the environment around them; show kindness and care and concern for other living things
	carry out assignments with determination, care, economy and honesty until successfully complete, and work happily with others
Grade 6	
Cognitive	structure and function of various systems of living things and relationships among diverse living things in different environments
Understand	properties and distribution of groups of materials; states of substances; properties of substances and causing change in substances; substances in daily life; simple methods of separating substances
	effect of force acting on objects; pressure; basic principles of buoyancy; properties and basic phenomena of light, sound and electrical circuits.
	characteristics, components and properties of the Earth's surface and atmosphere; relationship between the sun, Earth and the moon, which affects natural phenomena
Psychomotor	
Posing questions	on what is to be learned;
Estimating	give estimates of several possible answers;
Planning, Investigating, and verifying	plan, investigate and verify by applying tools and devices
Analyze data, communicating	analyze data and
	communicate knowledge obtained from investigation and verification
Applying	scientific knowledge and processes in life and search for additional knowledge;
Implementing	implement projects or tasks as prescribed or in accord with their interests
Attitudes	
Interest, determination responsibility, care, honesty	show interest, determination, responsibility, care and honesty in seeking knowledge
Aware and respect	are aware of the value of knowledge of science and technology; show appreciation, honor and respect of inventors' rights to their achievements
Recognition and concern	show recognition, care and concern as evident in conscientious behavior for utilization, protection and conservation of natural resources and the environment
Constructivist	work constructively with others; be ready to express their opinions and recognize views of others

Figure 2. Science Learners' Quality of Grade 3 and Grade 6

Primary science also covers the practical part of science, i.e. doing some experiments or projects which are totally guided by the teacher. Hence, it can be assumed that the low level of inquiry has been commonly opted as one of the learning strategies in Thailand's primary schools. The differences between lower and upper primary science activities can be noticed in the different type of psychomotor activities. The sixth graders are expected to develop higher-level activities, i.e. estimating, planning the experiments, carrying out investigations, and analysing data (Figure 2).

Domain	Intended Learning
Grade 9	
Cognitive	characteristics and main components of cells of living things; relationship of function in various system; genetic transmission; biotechnology; diversity of living things' behavior and responses to stimuli in the environment
	components and properties of solutions; pure substances; transformation of substances through change of their state; solution forming and chemical reaction
	frictional forces; moment of forces; variety of motion in daily life; rules for energy conservation; energy transfer; heat equilibrium; reflection, refraction and density of light.
	relationship between electrical quantities; principles of electrical domestic circuits; electrical energy and basic principles of electronic circuits
	change processes of the Earth`s crust; geological sources; factors affecting atmospheric change; reactions within the solar system and effects on various things on Earth; importance of space technology
	relationship between science and technology; development and effects of development on quality of life and the environment
Psychomotor	
Posing Questions	pose questions with prescription and control of variables;
Estimating	give estimates to several possible answers;
Planning, Investigating, verifying, analyzing, evaluating, creating	plan, investigate, verify, analyze and evaluate data conformity and create bodies of knowledge
Communicating	communicate thoughts and knowledge obtained from investigation and verification through verbal or written presentation, display, or application of information technology
Applying	apply scientific and technological knowledge and processes in life and seek additional knowledge;
Creating	create projects or work pieces in accord with their interests
Attitudes	
Interest, curiosity, responsibility, caring, honesty	show interest, determination, responsibility, care and honesty in investigating and seeking knowledge by applying instruments and methods that provide reliable results
Respect to science	aware of the value of scientific and technological knowledge applied in daily life and livelihood; show appreciation, honor and respect of inventors' rights to their achievements
Recognition and concern	Show recognition, care and concern, as well as appreciate behavior for utilization and conservation of natural resources and local environment
Constructivist	work constructively with others; be ready to express opinions and acknowledge views of others

Figure 3. Science Learners' Quality of Grade 9 (lower secondary)

The concepts to be understood at the lower secondary level are more complex and detailed, whilst the skills of inquiry that students have to acquire are also extended, as students have more opportunities to apply the complicated steps of inquiry. It absolutely provides more student autonomy. On the contrary, the teachers' authorities or guidance are decreased gradually in this level. It can be concluded that free inquiry is being introduced at this level. This is revealed by the type of hands-on activities that lower secondary students have to do. At the highest level of psychomotor activities of Grade 9 (equal to Grade 3 of lower secondary), students are targeted to create

a project or work piece suitable with their interests. In this activity, students apply the highest level of inquiry (Figure 3).

The common steps of science activities determined by the Thai science curriculum in all levels of school start with teachers posing questions, and this is actually the first step of the inquiry process (Figures 2 and 3). Students in the primary level will be trained to use basic scientific methods to explore their basic scientific process skills. The skills will then be expanded to integrated scientific process skills at a higher level of school by doing some investigations and free project activities.

Science Teachers' Perspective and Practices

Both respondent teachers are Filipino, who essentially have their own cultures which may directly or indirectly influence their thoughts and perspectives on science. They might belong to at least three kinds of cultures, i.e. Philippine, Thai, and global perspectives. However, science teachers, regardless of their nationalities, will probably show the common perceptions on science and science education. In this research, the impacts of culture, particularly the original culture of respondents, are not carefully considered. However, we tend to regard the school culture of Thailand as more important than the original cultures of the teachers.

Teachers A and B have different styles of teaching and perspective on science (Table 4). Teacher A seems to have a very strong perception of what science education means. This is revealed by the words she used to define science: *a body of knowledge for living thing survival, constructive or destructive, a way to answer the curiosity of nature phenomena, and how the universe works*. She also focuses on hands-on activities as a prominent approach to learn science. Meanwhile, Teacher B said science is a fun study of natural phenomena. He also described himself as a facilitator of science learning, and thought that science should be contextually learned (Table 4).

Table 4
Teachers' perspective on science and science teaching

Question	Teacher A	Teacher B
1. What is your perspective about science?	Science as a body of knowledge for me h*as a vital role in our survival;* not just to humanity as well as to everything as a whole. As what one of the Seven Environmental Principles states: everything is connected to everything else. *Science could become destructive and constructive to all living organisms.* Ever since, I am always fascinated by how magical and mystical our world is. Only science was and is able to satisfy my curiosity about the world. It is an *important building block for us to understand how the universe works*	Science is *fun*. Science is *a study about natural phenomenon*, all things that happened in nature.

Table 4 *(continue)*

Question	Teacher A	Teacher B
2. What is your perspective about science learning?	As a secondary school science teacher, school curriculum should always allow students to *explore and learn through hands-on experiences.* Students from this generation needs *more tangible activities* for them to appreciate and realize the significance of knowing the science concepts. Learning these concepts should be *based on how students can apply what they are learning in their everyday life*. The school itself must also *embody the usefulness of science ideas* not just the literal concepts of it. Some initiatives can be done by the students such as creating environmental awareness campaigns and other methods of addressing pollution.	Teacher as a facilitator in science learning should give the students any instructions to *understand the environment around them. Science learning is contextual learning*, students can learn from their environment.
3. What is the aim of science teaching and learning?	As a science teacher, I always put into my mind that I have a key role in preserving the world. It is not just about who can memorize every single word in the science book. It is about *how the people (students in this case) will make use of what they know to save our dying world*. Teaching science is *all about innovation* but it should not end there. The end goal for it should be on *the conservation of all life forms*.	Science teaching and learning is to help students *understand science concepts*, so they have *science skills, knowledge, and value*, then *apply it in their real life*.
4. How is your method to teach science?	For me, the strategy that I use will *depend on who is my audience*. But personally, since I am a visual learner, I prefer *videos, experiments, and group activities.* Most of the time, after the lesson proper I give students *practice worksheets just to check how much they have absorbed from the lesson.* If necessary, *reinforcement* is needed it will be addressed first prior to the next set of tasks. Once everything is relatively on track, we will proceed to a more rigorous yet enjoyable *question and answer* portion. I always encourage the *students to raise a question* whether or not it is related to the topic. *Formulating questions triggers the brain to reason out and make conceptual connections*.	By using *some strategies that match with the science topics*. That strategies *focus on student oriented or student centred learning*. I give them *video, ask them for doing some experiments. I give students' some group work with games and reward* that relate with the topic, so science will be fun.

Teacher A has realised her important role, that she is a main actor of a long-term investing process of preserving the next generation, who will be the citizens of the future world. She shows strong initiative and understanding of how science strongly impacts on the preservation of human life. She believes that the aims of teaching and learning science should be related to the effortful conservation of the place of human beings. In contrast, Teacher B sees science as knowledge, skills, and attitudes that students have to apply in the real world.

The perspective of teachers on IBSE can be found in their answers to the fourth question on how to teach science (Table

4). Teacher A suggested a process in which students will first be stimulated to enjoy science then to pose inquiry questions. She applied certain steps on her science class, beginning with showing the visual representations of science concepts, doing group-based experiments and other activities. Teacher B did not clearly describe his steps in teaching science, but both often presented video and did reinforcements through motivational words or rewards.

According to Panjwani (2015), teachers focus on student autonomy as most prominent in their perception of inquiry-based approaches to science teaching. Teachers also assumed that content knowledge of the curriculum and its connection with the real world is as important as student autonomy. This argument agrees with what both respondent teachers of the present research expressed about contextual learning based on phenomena in students' daily life, and hands-on experiences.

Yuenyong and Narjaikaew (2009) said that a key goal of science education in Thailand is to help and facilitate students to think about and relate science, technology and society. To actualise the vision proposed in the educational reform of Thailand, the science curriculum should be relevant to learners' real-life experiences.

Both respondent teachers cooperatively designed one document of syllabus for each semester. The first page of the syllabus is a general description of the topic of science covered in one semester. The second page informs the standard of science learning for each grade and semester, the time allocation in one semester, and the minimum standard of students' achievement in formative and summative tests.

Based on the syllabus analysis, it was found that, in the early grade of lower secondary, students are taught the topic of how to learn science, which is an introduction on the meaning of science, scientific methods and attitudes that scientists should have, and the role of science in promoting wellbeing in human life. During this session, students will learn inquiry-based science as a content and a method.

Analysis of IBSE practices based on the Lesson Plan and Classroom Activities

Though teachers have different perspectives on developing a lesson plan, they have to deal with the rules of four points: a) topic or content, objectives (cognitive, affective, and psychomotor); b) activities of 3I, i.e. Introduction (routine activity, motivation), Interaction (activity proper), and Integration (post-activity discussion, generalisation, assignment); c) key ideas; and d) evaluation or student assignments.

According to Wong and Wong (2009), teachers pose some initial questions to draft a lesson plan, such as what will be studied and obtained by the students after the lesson, how to facilitate students to achieve learning objectives, and how to do evaluations. Meanwhile, Cicek (2013) argued an effective lesson plan is to manage the classroom and time allocation by directing students with routine activities from the beginning to the end of the class.

The IBSE activities of respondent teachers were checked based on the main steps of inquiry, i.e. identifying problems, posing research questions, reviewing literature, generating hypotheses (if needed), investigating to collect data and information, constructing models, communicating the results, and forming coherent arguments.

An example of a lesson plan constructed by one of the respondent teachers shows that the science learning process has applied part of an inquiry-based learning process (Figures 4a and b). One lesson plan document consists of topic forms of energy, electricity, and solar system. In the topic of energy, students learn about energy with a set of activities provided by the teacher. During activity 1 (topic: similarities), students are directed to identify different forms of energy by sharing their ideas about energy and different forms of energy ("*Students are expected to participate and share their ideas to the class*"). In the next step, students pose questions by sharing their opinion ("*The teacher will call on some volunteer students for their insights and opinion*"). Activity 2 consists of the third step which is to generate hypotheses or argument based on the facts found by students. Students work in group, and then make illustration to generate hypotheses ("*Using an A4, the group must illustrate one system that will show the at least five forms of energy that is being transformed to another energy*"). The fourth step is to do investigations and collect data. This step is done during activity 3, whereby students are asked to fill in the workbook individually within the given time limit, and communicate the results ("*Students are expected to answer and hand over their work promptly*").

During activities 4 to 9, students are assigned to do relatively similar steps of inquiry as in activities 1 to 3, but for different topics; topics on electricity in activities 4 to 6, and the ones on solar system during activities 7 to 9. This started with identifying topics from power point slides or videos, filling in the workbook (collecting and analysing data), and finally communicating the results.

In the evaluation part, students have to show the transformation of energies through drawing. At the end of the learning process, the teacher will do a confirmation of the concepts by giving a summary, and asking some students to express some important points they have learned (Figure 4a). Based on the workload of teachers and students, it can be said that although the activities are mostly student-oriented, the teacher's guidance is relatively crucial.

Lesson Plan 11 **Subject: Science**
Matthayom: _3_ Time: _6__ periods
English Program, Chiang Rai Municipality School 6

1. Contents

*Forms of Energy
-Transformation of Energy
-Kinds of Energy
*Electricity
-What is electricity
-Factors of Electricity
*Solar System
-Nine Planets
-Characteristics of each planets

2. Objectives

During the session, the students will be able to

- Cognitive
  *Identify the different forms of energy;
  *Compare each form of energy;
  *Define electricity;
  *Give examples of sources of electricity;
  *Cite common hazards of electricity;
  *Identify the factors involved on electricity;
  *Explain the characteristics of each planet;
  *Show some advances related to space;
- Psychomotor
  *Show the transformation of energies through drawing;
  *Answer the activities in the workbook and textbook;
  *Participate actively in doing the group and individual outputs;
- Affective
  *Share one's experiences and ideas to the class; and
  *Listen attentively as others express their ideas.

3. Activities

Activity #1 Discussion on Energy

- The teacher will show a power point presentation on the different forms of energy.
- In here, some examples of energy transformations will be given to the students.
- Students are expected to participate and share their ideas to the class.
- The teacher will call on some volunteer students for their insights and opinions.
- This lesson will serve as a review for the students

Figure 4a. The first page of the lesson plan prepared by the teachers

Activity #2 Output on Transformation Energy

- The students will be asked to work in groups of three.
- Using an A4, the group must illustrate one system that will show the at least five forms of energy that is being transformed to another energy.
- They are to use a car as their system.
- They are to do this until the end of the session.
- They have to submit by next day
- The members of the group are expected to contribute in the output for their group.

Activity #3 Textbook Activity on Energy (page 107-109)

- The students will be asked to answer the activity in their Textbook on Energy found in pages 107-109.
- They are to do this individually and within the given time limit.
- They are to submit their Textbook by the end of the session.
- Students are expected to answer and hand over their work promptly.

Activity #4 Video on Static Lucian

- The teacher will show a video clip on electricity.
- The video shows a boy sliding down a plastic slide in a public park.
- After reaching the bottom of the slide his hair stood up.
- This phenomenon shows a static electricity.
- After watching the video clip, the teacher will call on some students to share to the class what they have in mind.
- The teacher will point out some key ideas given by the students.
- The class will also be expected to listen attentively and to give their ideas

Activity #5 Video on Electric Shock

- Another video clip will be shown to the students.
- This video is about a common event related to electricity which is electric shock.
- A boy was electrified after unknowingly touching a grounded pole.
- It took a long time for bystanders to notice his situation.
- When someone took him out of the people, he was not harmed.
- After watching the video clip, the teacher will call on some students to share to the class what they have in mind.
- The teacher will point out some key ideas given by the students.
- The class will also be expected to listen attentively and to give their ideas.

Activity #6 Textbook Activity on Electricity (page 145-146)

- The students will be asked to answer the activity on Electricity found in their Textbook on page 145-146.
- The students will work individually and within the given time limit.
- The teacher roams around to check the progress of the students and to be of guidance to students need clarifications.
- The students are expected to answer the activity diligently and to submit their work promptly.

Activity #7 Discussion on Solar System

- The teacher will show a power point presentation on Our Solar System.
- A thorough discussion of each planet will be given to the students.
- They are expected to listen attentively and to jot down important points in the discussion.
- Some volunteer students will be called to share their ideas to the class.
- The teacher will enrich the concepts shared by the students. students will be asked to answer the activity on Electricity found in their Textbook on page 145-146.

Figure 4b. The second page of the lesson plan prepared by the teachers

Activity #8 Video on How Big is the Earth?

- The teacher will present a video clip on How Big is the Earth?
- This clip shows a macroscopic size difference of the planets from other heavenly objects.
- Some stars and satellites will be included for comparison.
- The students are expected to watch the video.
- After watching, the students are expected to share their realization and their ideas to the class.
- The teacher will give a summary of all the ideas shared by the students.

Activity #9 Video on Free Fall

- The teacher will present a video clip on the experiment did by the Apollo 11 crew regarding Free Falling objects as claimed by Galileo Galilei.
- In the video, a crew dropped a hammer and a feather at the same height and at the same time.
- Both objects landed on the moon's ground at the same time despite the mass difference the objects.
- After, the students will be asked to give to the class their opinion on what they have just seen.
- Other students are expected to enrich the discussion through sharing their personal views.
- The teacher will wrap all the ideas of the students as one.

4. Evaluation/ Tasks

- The class will be divided into groups of three and they are to use in A4.
- They have to show an illustration of car with at least five forms of energy being transformed to another form.
- They will be given enough time to work as a group.
- They are to submit this by next day.
- They are to answer them within the given time and to submit them right after.

5. Summary

- Students will now be asked to go back to their original places.
- The teacher gives a summary of the lessons to concretize the concepts discussed.
- Some students will be asked to share to the class some important points they have learned after having the lesson.
- The teacher will enrich the ideas of the students.
- They will be asked to raise clarifications and questions before ending the session

6. Appendix (work sheet, test paper, workbook, etc.)

Teacher's Signature

Figure 4c. The third page of the lesson plan prepared by the teachers

Following Tafoya's idea, it can be said that the inquiry process shown in the given lesson plan is categorised as *structured inquiry*, where problems and procedures are both provided by the teacher, and students formulate the solution. The observation of the science classroom indicates similar inquiry activities as constructed in the lesson plan. Both teachers have adopted the IBSE and applied the structured inquiry level (Table 5).

Table 5
The level of inquiry practised in the observed classes

Class	Topic	Level of Inquiry
M 3.12	Energy	Structured Inquiry
M 1.9	Mixtures	Structured Inquiry
M 1.12	Mid-term Test	
M 1.9	Solutions	Structured Inquiry
M 1.11	Solutions	Structured Inquiry
M 2.11	Earth	Structured Inquiry
M 2.10	Earth	Structured Inquiry
M 1.10	Solution	Structured Inquiry
M 2.12	Soils	Structured Inquiry

Inquiry-based learning involves students actively participating in the learning activities that are related to knowledge development such as orientation, formulation of a hypothesis, experimentation, and conclusions (Joyce & Calhoun, 2009), which exist in the practices of science learning of both the respondents. However, the step to nurture student's ability to pose questions as the fundamental step to do investigations remains lacking.

Both the teachers have applied what the science learning and teaching process should be, such as to follow the general 5E instructional model introduced by Lin et al. (2014). The model involves a systematic learning and teaching strategy which consists of: 1) *engagement*, students use learning activities to make relations between prior knowledge and newly introduced concepts. The teacher demonstrates certain activities or poses questions to hold the interest, attention and motivation of students; 2) *exploration*, students use their hands-on experiences to discuss science concepts and skills. It is necessary to afford students adequate time to explore the ideas or situations that they face during the engagement phase; 3) *explanation*, this phase helps students create and develop scientific concepts and skills. Teachers ask students to explain the concepts or skills that they have observed or learned through previous activities. The teachers draw a conclusion and introduce formal science concepts to students; 4) *elaboration*, students apply the scientific concepts they have learned in a new context. Students may gain better comprehension of the information they have learned; 5) *evaluation*, teachers evaluate students' understanding to assess educational outcomes. Evaluation should be carried out as a part of each phase of the learning activities (Lin et al., 2014).

For example, in the first observation in M 3.12, students did some activities to learn about energy. First, students were asked to give attention the teacher's powerpoint presentation about different forms of energy, and then they were encouraged to share their ideas, insights, and opinions about energy to the class. This indicates the *engagement phase.* The *exploration phase* occurred when the students worked in group and made illustration about energy. Then, the teacher called on some volunteer students to present their work, which is the *explanation phase*. The *elaboration phase* took place when the students completed the activity in their workbook and wrote the answer in the whiteboard. In the *evaluation phase*, students showed the transformation of energies through drawing.

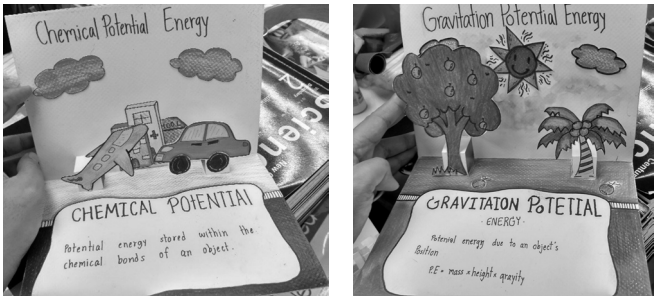
Assessment and Student Performance

Assessments are used to measure students' learning outcomes (Liu, Lee, & Linn, 2010). Most of the assessment system used in Thai science classes is to test students' understanding of science concepts, and strongly focuses on ensuring a long-term retention of the concepts (Table 6). Teachers assessed the students' understanding with paper tests in multiple choices or essays in their workbooks and worksheets, which mostly test low level of cognitive process, i.e. remembering or recalling the concept.

Table 6
Criteria to assess the output and group work

Criteria of Outputs (poster, mind map, journal, etc.)	Score	Criteria of Group Work	Score
Content/ Relevance	15	Delivery	9
Creativity	7	Content	6
Promptness	3	Teamwork	5
Total	25	Total	20

On some occasions, the teacher used authentic assessment. Authentic assessment is one which aims to evaluate students' abilities in real-world contexts such as when the teacher demonstrates an event, case, or problem in the real world and the students have to explain their ideas and thoughts about the case or problem and relate their ideas to the learning concept, so they learn how to solve real-world problems. The students are often directed to make posters, reports, presentations, and do performances or role play as the tasks. An example of students' poster in the energy topics (Figures 5a and b) indicates conformity with the task given by the teacher in the evaluation phase. The products made by students point out the creativity proven by the representation of concepts acquired, and the critical thinking as result of inquiry-based learning processes.



(a) (b)

Figure 5. Students' project 3D-Poster for science illustration: (a) Chemical potential energy, (b) Gravitation potential energy

The assessment that the teachers conducted in the science class (Table 6) showed conformance with the assessment in the science inquiry. Geier et al. (2008) explained that when students have an opportunity to interact with inquiry tools and engage in science-classroom activities, they would demonstrate improved learning in assessment closely related to the learning activities and curriculum. Therefore, in addition to evidence of learning on project-produced assessment, evidence of progress is also needed in the assessment.

According to Pravalpruk (1999), the assessment of science in Thailand is mostly assessing knowledge and recalling of scientific facts, processes of science and scientific skills, application of scientific knowledge, as well as attitudes and habits of mind acquired through science education. The assessment procedures are in the form of students' work and reports, practical tests, teacher observation of practical work during the semester, open-ended paper-and-pencil tests, and parents' and peers' comments and critiques. Results of the assessment will be converted into scores to measure students' learning outcomes.

CONCLUSION

The structure of the science curriculum in Thailand has already adopted the inquiry-based science education concepts as widely known, although it does not mention the term precisely. The curriculum starts by introducing the basic concept and method of science, and ends with the application of science as knowledge and methods to solve problems and address science in the interconnection between the society and technology.

The practices of inquiry learning by teachers, as an interpretation of the Thai science curriculum, were also shown as the partial steps and can be categorised as structured inquiry. However, based on the classroom observations, it can be concluded that inquiry has probably been a school culture of the observed school. Enlarging the area of studying and the number of teachers participating should enable us to analyse the teaching culture of Thailand's science teachers, and also recognise whether or not the IBSE has become a school culture in Thailand.

ACKNOWLEDGEMENTS

This research was done during the Sea-Teacher Programme organised by SEAMEO, hosted by the Chiang Rai Rajabhat University Thailand, and the Chiang Rai Municipality School 6, Thailand.

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