Thai students’ decision making about energy issues: the influence of local values

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Abstract

This paper reports on Thai students’ decision making about energy issues using teaching and learning based on a science, technology and society (STS) approach. The participants consisted of 132 Grade 9 students from three different schools in Khon Kaen, in North East Thailand. The three participating teachers in these schools had adopted the STS energy unit that developed by researcher. Teachers had attended workshops before and during their adopting the unit. The students’ decision making was investigated through participant observation and informal interview. Findings revealed students from the city seemed to make decision based on the knowledge from textbooks compared with students from the rural area. However, their decision making was not only developed based on scientific knowledge but also based on their value judgments that were made based on social economic and environmental aspects. The process of their decision making reflected that value clarification was different among three schools. The paper will discuss students’ normative decision making across three different schools and the implications of these results for better understanding socio-cultural views of learning, especially in relation to science teaching and learning in Thailand.

1. Introduction

The goal of Thai science education is to assist students to develop thinking skills by considering the relationship between science, technology and society. This goal requires that people have a multidimensional scientific and technological literacy in order to make decisions about issues of science technology and society that affect living across the world (IPST, 2002). To attain the goal of science education, Thai science teachers in general agreed with the need for making science teaching more meaningful by emphasizing student-centred learning and a concern for life-long learning that should play on the relationship between science, technology and society. The goal of Thai science education was addressed along with these crucial aspects of educational reform. With the attempts for obtaining education reform, one of them involved science teaching and learning that emphasized knowledge rather than a chance for practice in analytical thinking, self-expression and acquiring knowledge by themselves.

The study of energy in Thai schools provides a good opportunity to explore how the reforms to Thai science education are being put into practice. The topic of energy raises many issues for Thailand and addressing those issues requires people who have the skills of thinking, problem-solving, and decision-making; and values that

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involve dealing with the interactions among science, technology, and society for local issues about energy. To solve these problems, the education reform raised crucial aspects of teaching and learning including a learner-centred approach and life-long learning. This suggests that students should have chance to be in touch and interact with all around them such as other people, nature and technology; and to apply learning methods to their real lives (ONEC, 2002a).

Learning theories have pointed to the importance of the socio-cultural view of learning. The socio-cultural perspective is concerned with the influence of cultures to interact in energy classroom (Billett, 1996). With the important view of socio-cultural learning, science educators are reminded the situated cognition. Situated cognition means that cognitive processes differ according to the domain of thinking and the specifications of the task context (Coll et al. 2005). This suggests that energy teaching and learning would be influenced by the different contexts and cultures. Thus, the values, norms, and beliefs of larger society; the culture of scientific community; culture of learners; and school contexts should be taken into account for energy teaching and learning in Thailand. Considering culture of Thai communities, the Thai norm is to respect seniority; therefore the Thai attitude is one of humility (Titthummo, 2004). In the classroom, learning science tend to lack discussion because students might believe that good students usually do not say anything that might oppose what the teacher is teaching. This seems to be an obstacle for science learning that require negotiating and the validating and interpreting data through social processes. To appreciate teaching and learning science, teachers and students need to perceive the nature of scientific knowledge, the characteristics of scientific communities, and how scientists can understand and develop scientific knowledge. An understanding of scientific knowledge is negotiated and the validity and interpretation of data through social processes. Scientific disputes bring the relationship between science and society into sharp relief, and provide a useful context for enquiring (Driver et al, 1996). Learning, therefore, should account the influences of technology and society context.

Social Context Influences on Energy Learning

There are many perspectives that society is taken involve in science and technology. Rosenthal (1989) scoped relationship between science, technology and society as two perspectives including social issues and social aspects of science. Social aspects of science involves focusing science and technology with aspects of philosophical, sociological, historical, political, economic, and humanistic. Social issues required scientific and technological knowledge to solve the social problems. The social issues related energy is one of social issues that impinge on everyday life. Citizens are often required to make decisions about socio-scientific issues. The problems such as nuclear energy, energy use, or pollution are issues on which scientifically and technological literate students and citizens need to make decisions under framework of social aspects (Bingle and Gaskell, 1994; Ratcliffe, 1995; Jones, 1997). The public decision making about social problems related energy required well understanding of energy concepts. However, literature review found that students are confused with assumptions of energy in science class room and everyday notions (Solomon, 1983a). In Thai context, the daily life conversation seems to affects energy concepts. Yuenyong et al. (2005) found that student perceived the law of conservation energy as saving energy. This student perception might be generated from socialized knowledge because there are, now, amount of advertisement and campaign for saving energy in Thailand. The gap between the two different domains of knowledge as everyday notions and scientific explanation should be closed. Crossing over from one domain of meaning to the other involves an abrupt discontinuity student thought. Lesson energy should offer the relationship between science, technology, and society in order to give students to generate continually and apply their scientific ideas in society. The central part of decision making is a critical examination of the relevant scientific knowledge involved (Bingle and Gaskell, 1994). Giving students to consider decision making about energy issues; it might enhance student meaningful learning energy because it serves the answer of why students need to study energy. This view is a broad consensus of improving scientific and technological literacy (STL) (Yuengyong and Narjaikaew, 2009).
Technological Context Influences on Energy Learning

Technology should be perceived as not only applied science but also economic, social, personal, and environmental needs and constraints (Jones, 1997). The technology should be perceived also a system involving an organization, procedures, symbols, new words, and a mind set (Conway, 1994). Technology as system theory, for example, Marx’s case, he developed a historical teleology of social progress in which the working class would ultimately own and control machinery as the means of production (Hansen, 1997). The perception of technology beyond sense of artifacts and applied science, it could be interpreted through the social process. Technology, therefore, is a range of human activities, value, judgments, definition of content and selection processes (McCormick, 1993). The technological knowledge and practices are socially constructed and context dependent and where human mental processes are situated within their historical, cultural and institutional setting. Interpretation of technology through social process involve technological developments that have been shaped by people making decisions based on their own and others opinions and interests. Hansen (1997) described the meaning of technology through social relation that raised the three types of cultural meaning of technology including the motivational, topical, and practical or interpretative meaning. The topical meaning corresponds with curriculum content, conceived as a selected part of the students’ reality. Motivational meaning refers to the interests people develop in technology and involves a social process of exercising choice in ways derived from cultural values and norms. The interpretive meaning of technology refers to the practical means of designing, communicating and understanding technology (Hansen, 1997).

With the deepen view of technology, it illustrates holistic view about how the technological context influence science (energy) learning. The influences of technological context raise the importance of providing citizen and suggest the relationship science and society, and scientific knowledge development. The understanding of what, why, and how ideas, design, systems, volition of application scientific knowledge and other knowledge (e.g., philosophical, sociological, political, economic, humanistic aspects and so on) work becomes key aspects of surviving in society. For example, citizens have to make decision about energy issues (e.g. energy use, saving energy, and pollution) that they requires technological idea. The technological view of design support public decision making. The focus on design links technology to general cognitive abilities. This aspect public rhetoric about energy and technology becomes dominated by dichotomies like ‘chances and problem’, ‘advantages and disadvantages’, or uses and abuses’ (Hansen, 1997). As goal of provide citizen, this suggests that energy learning should account technological aspects for enhance students to perceive the relationship between science, technology, and society.

Process of Decision Making

The influences of science and technology context suggest that decision-making should be taken into account for energy learning. The decision making requires people who have higher order thinking skills to apply value judgments and other knowledge (Kortland, 1996, Bingle & Gaskell, 1994; Ratcliffe, 1997). Decision making is perceived as a process that has to do with issues, solutions, values, action taking (Ratcliffe, 1995; Kortland, 1996). As a process, decision making is the making of reasoned choices from among alternative courses of action that concerning a personal or public issues, which require judgements in terms of one’s values. This process ideally should proceed have led to the formulation of a normative model for the decision making process (Kortland, 1996). Normative decision making models give a logical structure of step-by-step processes which should be undertaken if rational decision making is to take place (Ratcliffe, 1995). In general, practical idea of normative decision making model is a step wise of procedure of identifying the nature of problem, developing criteria, generating and evaluating alternatives, and finally choosing and implementing the best solution (Ratcliffe, 1995; Kortland, 1996).

To provide framework of examining and describing student decision making for carrying out research in science education, the framework of normative decision making model was employed quite similar by Kortland (1992, 1995, 1996) and Ratcliffe (1995, 1997). According these research, the common themes of the normative decision making model could be concluded as containing six steps.
(1) Options. List or identify the possible alternative way of action in considering the problem or issue.

(2) Criteria. Develop or identify suitable criteria to use for comparing these alternative ways of action. The nature of these criteria is left open to discussion.

(3) Validity and clarify of information of each criterion. Clarify the information known about possible alternatives, with particular reference to the criteria identified and to any scientific knowledge or evidence.

(4) Evaluation or survey. Evaluate the advantages and disadvantages of each alternative against of the criteria identified. Or, weight conflicting results of the comparison on different criteria.

(5) Choice. Choose an alternative based on the analysis undertaken.

(6) Review. Evaluate the decision making process undertaken, identifying and possible improvement.

Goal of science education expected students to understand the relationship between science, technology and society. The framework of normative decision making model suggests how to support students to consider the factor of relationship between science, technology and society. Lesson energy may give chance students to learn energy related decision making in group discussion or individual about energy issues, might enhance student learning to achieve goal of science education about understanding the relationship between science, technology and society. Next discuss about teaching through the science, technology and society approach.

Energy Learning through Science, Technology and Society (STS Approach)

Entering the relationship between science, technology and society in the energy class would be a possible solution because it supports energy learning by negotiating and disputing scientific knowledge through a socialisation process (Aikenhead, 1994b). The issues about energy such as energy use, energy saving and pollution would enable students to realize the relationship between science, technology and society. The issues require students or citizens to make decisions under a framework of technological and social aspects. The social aspects involve focusing on science and technology with aspects of philosophy, sociology, history, politic, economic, and humanistic. Central to decision-making, technology is a crucial skill for citizens who need to consider multidimensional aspects in their decisions such as any social constraints (Bingle and Gaskell, 1994; Ratcliffe, 1995; Jones, 1997). Broadly speaking; technology is the ideas, designs, systems, volition of scientific applications and other knowledge that is socialised by values and norm before becoming products (de Vries, 1996; Hansen, 1997). The STS Energy teaching and learning, therefore, would allow students to learn energy through decision making for energy issues. According to the different goals of STS there are several ways of attaining STS objectives. The research emphasizes developing the STS energy unit to allow students to learn energy through solving the issues about energy regarding Aikenhead (1994a) sequence for STS science teaching as showed in Figure 1. Teaching and learning is started from society realm and moved to acquiring technology, and science concepts and skills. Finally, students have chance to take action in society.

![Figure 1](https://example.com/figure1.png)
According Aikenhead (1994a) sequence, the unit should give students chances to identify problems with local interests and the impacts about energy related technological and societal issues. The Unit will, then, allow them to experience citizenship roles as they attempt to resolve issues they have identified. The framework of teaching the STS energy unit, therefore, consists of five stages including (1) identification of social issues, (2) identification of potential solutions, (3) need for knowledge, (4) decision-making, and (5) socialization stage (Yuenyong, 2006).

2. Methodology

This research is conducted regarding the interpretive paradigm. Interpretive research seeks to describe and interpret human behaviour based on their natural setting rather than form laws about it (Marriam, 1998; Cohen et al., 2000). Concerning the issue of dependability, therefore, a clear description of how data was obtained and open acknowledge of context should be taken into account. The study enters the relationship between science, technology and society in energy teaching and learning through STS approach. The research was designed to be carried out in the different school contexts in Khon Kaen province including schools in the city, a small town, and a rural area. As the process of interpretation, this study aims to interpret students' normative decision making across three different schools and the implications of these for science teaching and learning in Thailand. The interpretation of data is based on fields work.

2.1. Participants

The research was carried with 132 Grade 9 students in the four different schools of Khon Kaen province where located in northeastern of Thailand. These schools included school B, C, and D. Each school context is clarified as following.

School B is located in the city, Khon Kaen province. The school has a total of 3,000 students in Grades 7 - 12. Kunya is the participating teacher of the school B. She graduated with a Bachelor of Education in home economics. She has 16 years of experiences teaching science. Kunya’s responsibilities include secretarial and administrative duties as well. Her participating Grade 9 science class includes 49 students, 37 girls and 12 boys, live in the city of Khon Kaen and other small towns near the city of Khon Kaen. Their parents work for businesses and government offices. The interesting source of energy learning in school B is the Green Classroom that provided and financially supported by the Electricity Generating Authority of Thailand (EGAT).

School C is located in a small town of the Khon Kaen province where far approximately 40 kilometres from the city of Khon Kaen. The school has a total of 2,500 students in Grades 7 - 12. Ann is the participating teacher of the school C. She graduated with a Bachelor of Education in science for lower secondary school. She has 14 years of experiences teaching science. Ann’s school load include not only science teaching but also working for the school academic affair. Her participating Grade 9 science class includes 47 students, 25 girls and 22 boys, who live in this small town and other villages near this small town. Their parents work in private businesses, government offices, and farms. The interesting source of energy learning in school C is the Green Classroom that provided and financially supported by the Electricity Generating Authority of Thailand (EGAT).

School D is located in a rural area of Khon Kaen province where far approximately 60 kilometres from the city of Khon Kaen. The school has a total of 600 students in Grades 7 - 12. Pim is the participating teacher of school D. She graduated with a Bachelor of Education in biology. She has 10 years of experiences teaching science. Pim’s school load includes biology and science teaching, head of science department, and head of school academic affair. Her participating Grade 9 science class includes 29 students, 18 girls and 11 boys, who their parents work as laborers in Bangkok and as farmer. The interesting source of energy learning in the school D is the solar power pumped water that was donated by an Australian organization.
| Sub-units          | Issues                                                                 | Activities                                                                 |
|-------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Generation power  | How can we find the solutions for the demand in electric energy and the problems of the power plant that polluted the air? | Identification of social issues stage:                                     |
| (8 sessions)      |                                                                         | • Brain storming to make the sceptical ideas about the Mae-moh power plant situation. |
|                   |                                                                        | • Conclude and categorize trends of question orientation.                   |
|                   |                                                                        | Identification of potential solution stage:                                 |
|                   |                                                                        | • Brain storming for possible alternative solutions of each oriented question category |
|                   |                                                                        | • Clarify the related knowledge known and unknown                           |
|                   |                                                                        | Need for knowledge stage:                                                   |
|                   |                                                                        | • Do experiment of electromagnetic induction with the simple dynamo          |
|                   |                                                                        | • Do experiment of electromagnetic induction with a simple dynamo            |
|                   |                                                                        | • Study the process of generation power in hydro and coal fire power plants |
|                   |                                                                        | • Num-pong power plant trip to attend engineer power plant conversation.    |
|                   |                                                                        | Decision making stage:                                                     |
|                   |                                                                        | • Plan and search more information for the role-play of the Mae-moh situation |
|                   |                                                                        | • Collect the background information to think of what and how will be the best volition of the Mae-moh situation |
|                   |                                                                        | Socialization stage:                                                       |
|                   |                                                                        | • Organize role-play of the Mae-moh situation as public hearing.            |
|                   |                                                                        | • Num-pong power plant trip to share engineer some alternative solution for the power plant that pollute the air. |

2.2. Methods of Inquiry

The three participating teachers in these schools had adopted the STS energy unit that was developed by the researcher. The STS energy unit consists two sub-units including (1) Use energy in Thailand (issue of the increased petrol price), (2) Generation power (issue of the Mae-moh situation). Example of unit outlined as showing in the Table 1. Participating Teachers had attended the workshops before and during their adopting the unit. The students’ decision making was investigated through participant observation and informal interview.

3. Research Findings

The STS energy unit raised students the energy issues that required decisions making. Students had chances to gain their understanding of what, why, and how ideas of application scientific and other knowledge worked through the process of decision making. Their decision making was not only developed based on scientific knowledge but also based on their value judgments that were made based on societal, economical, and environmental aspects. As a process of decision making, students across three schools normative decision making could be viewed including identifying possible way, developing criteria for decision making, validity and clarification of information, selecting an alternative and reviewing the possible improvement. Students’ decision making for the issues of the increased petrol price and the Mae moh situation are clarified below.

3.1. Students’ Decision Making on the Issue of the Increased Petrol Price

Sub-unit one of the STS energy allowed students to make decision on alternative actions for the situation of the increased petrol price. Students’ process of decision making elaborated them to their value judgments concerning with scientific knowledge, economical aspects, helping society, environment concerns, people behavior, and the use of local materials. This could be viewed as the overview of the three schools students’ process of decision making that would be clarified as below.

School B students began their decision making process with listing the possible alternative ways of action. These include organizing project of electric energy and petrol saving, the alternative energy sources (e.g. bio diesel,
gasohol, bio gas, biomass, and solar power). Then, they clarified information for alternative ways of action. Their clarifications could be divided into two aspects including reviewing literature about scientific knowledge and doing experimentations. Students’ literature review involved petrol saving strategies, and knowledge of alternative energy. For example, Kaew’s group clarified the strategies of petrol saving; and Phan’s group did biogas experiments.

The strategies of petrol saving include 1) car pool, 2) walking or use bicycle in case of short traveling, 3) check car’s engine before traveling, and 4) refuel the gasohol. (Kaew’s group)

… Material and equipment include 1) bucket for mixing water and organic matter, 2) organic matter (i.e. excrement, and leaving food), 3) pure water, and 4) a plastic tube. The methods, there are two steps. Firstly, Mix 1/3 bucket of water and 1/3 bucket of organic matter. Secondly, completely close the bucket. Leave the bucket for 7 days. After 7 days, hole the bucket, and then employ a plastic tube to connect the bucket to a gas stove. Ignite a fire, and then observe and measure thermal. … (Phan’s group)

Their possible ways of action were evaluated concerning with economical aspects, helping society, and local materials use. For example, students considered the farmers’ income when the cassava as local material was used to produce ethanol for gasohol. Gaining profit from the leaving materials was also considered by school B students. For example, Phan’s group decided to do experiment on biogas because they appreciated the left-over in the restaurants and the temples.

Students: Is it worthwhile to produce the biogas. How much does the methane result?
Phan’s group: Yes, it is because we don’t pay. It’s free but it is not convenient. Biogas may be suitable for temples and restaurants where there is amount of left-over food. Pig farms also are suitable place. I have seen Ban Sumran Temple’s biogas station. It works.

Additionally, it seemed that school B students considered multidimensional aspects for solving problems. For example, Kaew’s group evaluated their campaign of petrol saving concerning with the traffic jam of the main road in the city of Khon Kaen and cost of a car using petrol.

Kaew’s group: Car pool is not only a strategy for petrol saving but also reducing the problem of traffic jam. There are many traffic jams in many parts of Khon Kaen city such as Malivan intersection, surrounding schools, and the bus center.

Students: I think that we must use amount of petrol when we use car pool strategies. Is it still saving petrol?
Kaew’s group: Yes, it is but it is worthwhile because many people are saver than many cars.
School C students listed possible alternative ways of action for this issue involving organizing project of petrol and electric energy saving. They focused on various samples including people in the town transport centre, the market, and their villages. Considering the sample suggested them find the ways of taking actions. Their information clarifications for alternatives could be divided into two aspects including review literature about scientific knowledge and survey of preliminary information. Students’ literature review include the origin of petrol, the limitation and advantages of petrol, the energy saving strategies of other organizations, and amount use of non-renewable energy sources in Thailand. Students’ survey for preliminary information include Cath’s group survey of people opinion about petrol saving, and Dear’s group survey of the peak of electric energy use a day in their village.

Cath’s group surveyed peoples’ opinion about the cause of increased petrol price and strategies of petrol saving that would be appropriate with their five villages. They concluded their survey as following:

The cause of increased petrol price includes: 1) the Iraq war, 2) the limitation of petrol in the world, 3) people did not save petrol, and 4) a high demand of petrol. The appropriate strategies of petrol saving for their five villages include: 1) speed limit 90 km/hr, 2) car pool, 3) stop engine during waiting, 4) check car engine before driving, 5) use a mass transportation. (Cath’s group)

Interestingly, Dear’s group aim involves people motivation by showing the big change of the village cost of electric energy. To focus their alternative taking actions, they survey of the peak of electric energy use during a day in Nong Waeng village. It was found that the peak was during 8 am – 12am. They found that a rice mill was the highest electric energy consuming that use electric energy around 33 kilowatt-hour during peak time. The example of how they collect data is showed in the Figure 2. Their survey allowed them to obtain the strategies of energy saving that would be appropriate with their communities. For example, Dear’s group created the Ten Rules of electric energy saving for the rice mills in their village. Their ideas concerned with the rice mill management, technique to mill the rice, and people behaviors. Their ten rules stated as below:

(1) Restrict time to receive the rice for milling only during 7am – 12 am;
(2) If the time out, the rest of rice will be done in a next day;
(3) A family can mill only 1 – 2 sack of rice a day;
(4) If a family cannot mill in the restrict time, the rice mill owner have to lend them three liter of rice;
(5) The rice mills have to mill the newly harvested rice with the same standard;
(6) People should go to a near by rice mill in order to be not crowded in a rice mill;
(7) The rice should be milled only a round because of energy saving and remaining the vitamins;
(8) In case of a mass and festivals, people should mill the rice bit by bit for storage;
(9) The rice mills should stop running by 6 pm; and
(10) The rice should be dried out and taken the chaff out before milling in order to save time for the rice mill working.

However, Dear’s group ideas were validated by the mill owners. This gave them to concern more the economical aspects. Dear’s group commented in their report:

… Restricting time is not appropriate because this is a business matter. The rice mill owners have to compete with each other for gaining more profit. For example, if the Daeng rice mill runs the machine for one hour to mill the 12 buckets, he will receive around 80 Baht. If he pays 20 Baht for electric energy and 10 Baht for cost of the worm machine, his profit will be 50 Baht. If he runs the machine 5 hours during 7 am to 12 am, he will receive 250 Baht. So, if he runs the machine 11 hours during 7am to 6pm, he will receive 550 Baht at least. We realize that the restricting time is not the point, therefore, we have to improve …

This assumed that the process of decision making allowed them to evaluate their possible ways of action concerning with people opinion, and economical aspects. Additionally, environmental concerns and country development were also raised, for example, Pron’s group concluded the advantages of petrol saving including “… government has money for the country development, carbon dioxide resulting from a car is decreased …”

School D students listed possible alternative ways of action for the issue of the increased petrol price involving organizing project of energy saving, renewable energy sources. Then, they clarified information that could be divided into two aspects including what they were supposed to do and review the related knowledge. Their evaluation for the possible alternative ways of action concerned with people behavior. For example, Dol’s group raised tactical strategies of energy saving campaign involving students’ value of the song listening. They planed to organize the school radio song program with inserting the strategies of energy saving. Dol explained:

Researcher: Why the school radio program?
Dol: It can reach to everyone. If we do the slogan board, we cannot promote this campaign to everyone.
Researcher: Why did you think that everyone listens to your radio program?
Dol: They like the song program. Our program will provide good songs and the details of energy saving.
They planned to organize the school radio song program with inserting strategies of energy saving. The tactic of time was concerned for Pla’s group. They believed that their persuasion about petrol saving would achieve if they allowed people to see the slogan board for a long period of time. As Pla explained:

Researcher: Why would your group like to campaign petrol saving through binding the slogan board around the tree?
Pla: ....a slogan board will tell everyone anytime.

3.2. Students’ Decision Making on the Issue of the Mae-moh situation

Sub-unit two of the STS energy allowed students to make decision about alternative solutions for the Mae moh coal power plant where polluted the air. The Mae moh coal power plant located in Lampang province, northern of Thailand. Students’ process of decision making elaborated their value judgments concerning with scientific and technological knowledge, energy sources supply, electric energy supply, environment concerns, health, safety, electric energy saving and economical aspect. This could be viewed as the overview of the three schools students’ process of decision making that would be clarified as below.

School B students considered whether the Mae moh coal power plant should be closed down or not. They clarified information possible alternatives including various kinds of the generation power, and the process of generating power. The Num-pong power plant trip, in Khon Kaen province, allowed school B students to compare and contrast environment effects between the Num-pong and the Mae moh power plant. Students tried to detect pollution that would be generated by the power plant. Some students probed the Num-pong power plant engineers as below:

Da: Are there any differences between the Num-pong and the Mae moh power plant?
Num-pong engineer (NP): ... It is quite similar. I mean the way it works. Only the fuel is used differently. The Mae moh fuel is the lignite coal but the Num-pong fuel is the natural gas. In Mae moh power plant, coal will be broken up powder, and then input furnace for boiling water. ...;
Muay: Why does this power plant have to provide a pond of waste water?
NP: OK. In the process of generating power, we have process for cleaning equipment. The water from cleaning was contaminated with some chemical substance. So, we need that pond. We remedied the waste water to water the trees in this power plant.

The school B students also clarified scientific knowledge about the generating power, for example, the close loop of boiling water, taking care of the generators, and distribution of electric energy. Students probed how the steam was managed as follows:

Muay: How can the power plant take the used steam out?
NP: We will not take it out. As I said earlier, it was a close loop. There, the steam will be used again and again. The close loop will be cooled to be water for reuse. However, it has a little water is lost.

Their evaluation for the possible alternatives could be viewed during the role-play of the Mae moh situation. As the role-play, students were separated into four groups including power plant officers, environment organization, government, and people who live in the Mae moh district. Each group received background information in each favor. They joined together to validate the advantages and disadvantages of each alternative. It seemed that their evaluation was made based on health, environment concerns, electric energy supply, and economic aspect. Regarding the role-play, school B students raised the issues of moving the people away, moving the coal power plant away from the communities, and constructing new kinds of the power plant. Then, these issues were validated concerning with health of people, environment damages, electric energy supply, and cost of constructing a new power plant. For example, students discussed as below.

Da (people role): all of us got sick because of the air pollution. How will you help us?
M.C: So, how would you help them the government representative?
Tik (government role): we have given you the compensation. If it still gives the bad atmosphere, I think people should move out the Mae moh district.
M.C: Why do people need to move out? Please give them reasons.
Tik: How can you move the power plant? It will lose a large amount of money for constructing a new power plant and many factories in the northern part will be affected because no power supply.
Alternative energy sources e.g. solar power were raised to substitute coal. Their value evaluation involved environment concerns and cost of new alternative energy sources power plant. As students discussed below:

Pron (ecologist role): the Mae moh power plant fuel is coal. Coal usually contaminated with sulfur, therefore when it was burn it would give the sulfur dioxide. When sulfur dioxide is released to the atmosphere, it affects the environment. Sulfur dioxide will affects people health. People have a chance get Nemoosese. Sulfur dioxide causes acid rain that makes environment damages.

Tik: I think that a solar power has no pollution but we have to pay a high cost of construction.

School C students considered whether the Mae moh power plant should be closed down or not. They clarified information of possible alternatives. Each group of students tried to propose the type of power plant that they were interested in for substitution coal power plant that affected the environment. Various types of the power plants were proposed including storage water power plant, geothermal power plant, and nuclear power plant. For example, the pumped storage power plant was proposed because they aware of water supply. As group 2 commented:

Group 2: The pumped storage power plant, pumped storage water up at high level and then let it flow down to turn the turbine. It might work even in the dry season. Did you know? Is there any energy spreading during the pumped storage power plant working?
Students: Yes, it is. Energy could spread out via the air, water, sun light and gravitational potential energy.

The geothermal power plant was raised because students thought that it did not affect the fresh air. They knew that the geothermal power plant was run in the resort, Chiangmai province, where they needed the fresh air as following their discussion.

Group 3: Why don’t we construct a geothermal power plant at the Mae moh?
Saharat: Should you ask the Electric Generating Authority of Thailand (EGAT)?
Group 3: So, why was the geothermal power plant constructed in the resort?
Dee: because the resort needs a fresh air.
Kay: Hey, what you asking is in the reading sheet.
Puy: Does the geothermal affect the environment damages?
Group 3: It might give the environment effect because this power plant is located in the research where fresh air is needed.

The nuclear power plant was also raised. However, their considering of the uranium supply and cost of constructing the nuclear power plant reminded them that it would be impossible for Thailand. As their discussion below:

Rin: Why doesn’t Thailand construct the Nuclear power plant?
Suda: I don’t know.
Teacher Ann: Any ideas?
Dee: It has a high cost of construction.
Thana: I think our country does not have technology.
Kay: Um … I didn’t read the reading sheet. I have no ideas …
Jas: Nuclear power plant employ the Uranium. Are there any sources of the Uranium in Thailand?
Rin: There are in other countries such as France, Australia …

The Num-pong power plant also was clarified. The Num-pong power plant trip allowed students to compare and contrast environment effects between the Num-pong and the Mae moh power plant. Students examined the Num-pong power plant. Students discussed as below:

... Cath: Does this power plant have any environment effects?
NP engineer: Good question. Sure, it has environment effects because it uses the natural resources. Here it doesn’t cause air pollution. Natural gas is used here that is clean energy. It is like your cooking gas in your home. …
Student: Will it be similar with the Mae moh power plant?
NP engineer: It uses a different fuel. The Mae moh uses coal to boil water but here we use natural gas. …
.... Suda: If the Num-pong power plant releases sulfur dioxide like the Mae moh power plant, how will you solve the problems?
NP engineer: The Mae moh use coal, therefore it gives the different chemical reaction from here. Here we use natural gas. It will give chemical reaction that containing carbon and nitrogen oxide. These gases were limited to contaminate in the air approximately 10 ppm but we found around here only 3 ppm. … it is safe for environment. Our health department always survey around the power plant. They never found any decease that was caused by the pollution. …

These indicated that their value clarification of various types of power plants concerned with energy sources supply, pollution, safety, and scientific and technological knowledge. Their evaluation for the possible
alternatives could be viewed during the role-play of the Mae moh situation. Students evaluated the advantages to keep running the Mae moh power plant concerning with the electric energy supply for the wide area use. They worried about the industrial use of energy that would affect to the Thailand economic. They believed that the air pollution problem could be reduced.

School D students considered whether the Mae moh power plant should be closed down or not. They clarified information possible alternatives including various kinds of the generation power, and the process of generating power. Students clarified various kinds of generation for the alternatives. Each group of students presented their interesting power plants and then discussed how it had no effects to the environment. These power plants included the solar, wind, nuclear, and geothermal power plant. Additionally, the Num pong power plant trip allowed them to discuss the scientific knowledge about the process of the thermal generating power and to provide information for the Mae moh situation. Students’ discussion to the Num pong power plant engineers focused on technical process of the generating power, budget, alternative energy sources, and environment concerns. Technical process of generating power was clarified. For example, students wondered how the steam could generate power, compared fuels generating power, and considered alternative energy sources use in case of the natural gas and diesel running out. As students’ discussion below:

Na: Which one will be better if we compare between diesel and natural gas?
Num pong engineer (NP): If we consider the capital, natural gas is better. If we consider the value of thermal, diesel is better.
Aom: How is steam used for generating power?
NP: It is used for turning turbine because the steam gives both temperature and pressure. The pressure can turn the turbine like the water flow through the turbine. ….
Korn: If natural gas and diesel runs out, what will be substituted?
NP: Our power plant was not designed for using other fuels. If there are not these two kinds of energy sources, it can do nothing. However, now, we found another natural gas source at the Phu hom in Udonthani province which would supply for many years.

Students’ clarification revealed their environment concerns. For example, they focused on the high temperature emitted air that could be affected the environment. As students’ discussion below:

NP: The cooler tower will let heat off. Its temperature is around 110 degree centigrade that there are no effects to the environment.
Na: How much will it affect to the environment?
NP: If it over 200 degrees centigrade, it might affect to the environment

Their evaluation for the possible alternatives could be viewed during the role-play of the Mae moh situation. Their evaluation was made based on safety and health, environment concerns, electric energy supply, electric energy saving, and the economic aspect. People safety and health were raised as the most important criteria for solving this problem. This could be viewed as presenting their three proposals for the alternatives. These proposals were made based on people’s health concerns as following.

…First, move away the power plant. Second, keep running the power plant with no pollution. Third, if the power plant still be here, government has to give people money to medicine all year long their sick as much as they need until they recover...

Environment concerns were also applied for evaluating possible alternatives. Students were aware of decreasing pollution. They proposed possible actions to decrease pollution problems. Finding alternative energy sources, no pollution effects, were considered. Students tried to identify energy sources that give no pollution. Available sources and its price were evaluated for possible alternatives. Additionally, the electric energy saving was raised in order to decrease the air pollution.

4. Conclusion

The findings showed that students across three different schools were enhanced process of decision making, giving ideas, investigation of scientific knowledge, and social responsibility. The issue of the increased petrol price gave students chances to learn energy concepts and applied knowledge to society. Students applied knowledge of energy forms and sources, and other knowledge to help their society solving the problem of increased price of petrol. Mostly, they organized the project of energy saving and alternative energy sources. Process of their decision making reflected that their value clarification was different among three schools. Students from the city seem to concern more on the knowledge from textbooks than students from the rural area. This would be influenced from value of taking entrance examination to the well known schools and universities. School B students valued
possible ways of action concerning with reviewing literature about scientific knowledge and doing experiments. School C students concerned with scientific knowledge, and people opinion. But, school D students concerned with people’s behavior. Students’ evaluation of way of actions reflected that they understood relationship between science, technology, and society. They evaluated possible ways for resolving the issues of increased petrol price concerning with economical aspects, helping society, country development, and using local materials.

Mae moh situation gave students chances to learn energy concepts and applied knowledge to society. Students applied knowledge of energy transformation and degradation, the law of energy conservation, and other knowledge to help their society solving the problem of the Mae moh situation. The Num-pong power trip allowed students across three schools to lively inquire scientific knowledge about generating power to apply for the Mae moh situation. For example, they probed engineers about close loop of boiling water, how steam generates power, pollution problems, comparing fuels generating power, and so on. Students’ evaluation of way of actions for the Mae moh situation during the role-play reflected that they understood relationship between science, technology, and society. They evaluated possible solutions concerning with multidimensional aspects. However, there were little different value clarifications between three schools. School B and D students seems to focus more on people’s safety and health, and environment concerns. They raised the issues of moving the people away, moving the coal power plant away from the communities, and constructing new kinds of the power plant which had no pollution. But, school C students strongly concerned aspect of country development. They perceived that the Mae moh power plant distributed electric energy wide areas. Closing down the Mae moh power plant would affect the industrial use of energy and Thailand’s economic. The air pollution from the power plant could be reduced.

This seemed that the STS energy unit allowed students to develop their normative model for decision making about energy issues related to technological and societal issues. Their value judgements were made a little bite differences depending on their local values. It would be mentioned that the STS energy unit could provide citizen who concerned on technological perspectives and perceived the relationship between science, technology and society.

References

Aikenhead, G. (1994a). What is STS science teaching? In Solomon, J. and Aikenhead, G. (Eds.). (pp.169 – 186). STS Education: International Perspective on Reform. New York, USA: Teachers College Press, Columbia University.

Aikenhead, G. (1994b). Consequences to learning science through STS: A research perspective. In Solomon, J. and Aikenhead, G. (Eds.). (pp. 169 – 186). STS Education: International Perspective on Reform. New York, USA: Teachers College Press, Columbia University.

Aikenhead, G.S. and Ryan, A. (1992). The development of a New Instrument: ‘Views on Science – Technology – Society’ (VOSTS), Science Education, 76(5): 447 – 491.

Aikenhead, G.S., Ryan, A., and Fleming, R.W. (1989). Views on Science-Technology-Society: Form CDN.mc.5. Available: http://www.usask.ca/education/people/aikenhead/vosts.pdf, July 25, 2003

Asian Development Bank (ADB). (2002). Teacher Development for Quality Learning: The Thailand Education Reform Project, March 2002. Brisbane, Australia: Office of Commercial Services, Queensland University of Technology. Available: http://www.worlddeform.com/pub/fulltext4.pdf,

Billett, S. (1996). Situated learning: Bridging sociocultural and cognitive theorising. Learning and Instruction, 6 (3), 263 – 280.

Bingle, W. H. and Gaskell, P. J. (1994). Scientific literacy for decision making and the social construction of knowledge. Science Education, 78(2), 185 – 201.

Carr, M. and Kirkwood, V. (1988). Teaching and learning about energy in New Zealand secondary school junior science classrooms. Physics Education, 23, 86 – 91.

Cohen, L., Manion, L. and Morrison, K. (2000). Research Methods in Education. London, UK: Routledge Falmer.

Coll, R. K., France, B., and Taylor, I. (2005). The role of models/analogies in science education: implications from research. International Journal of Science Education, 27 (2), 183 – 198.

de Vries, M. J. (1996). Technology education: Beyond the ‘technology is applied science’ paradigm. International Journal of Technology and Design Education, 8(1), 1 – 6.

Driver, R., Leach, J., Millar, R., and Scott. P. (1996). Young People’s Images of Science. Bristol, Philadelphia, USA: Open University Press.

Hansen, K. 1997. Science and technology as social relations towards a philosophy of technology for liberal education. International Journal of Technology and Design Education, 7, 49 – 63.

Institute for the Promotion of Teaching Science and Technology (IPST). 2002. The Manual of Content of Science Learning. Bangkok, Thailand: Curusapha ladphoa.

Johnson, A. (1992). Educational options for the future of Thailand. TDRI Quarterly Review, 7(1), 3 – 7. Available: http://info.tdri.or.th/library/quarterly/text/m92_1.htm
Jones, A. 1997. Recent Research in Learning Technological Concepts and Processes. International Journal of Technology and Design Education. 7: 83 – 96.

Kaewdaeng, R. 2003. Educational reform in Thailand: the view from an insider in story by Fredrickson, T. The Bangkok Post. Available: http://www.bangkokpost.net/education/site2003/cvse2303.htm

Merriam, S. B. (1988). Case study research in education. San Francisco, USA: Jossey-Bass.

Office of the National Education Commission (ONEC). (1998). Crisis of Thai Science Education. Bangkok, Thailand: ONEC.

Office of the National Education Commission (ONEC). (1999). Education in Thailand 1999. Bangkok, Thailand: Wattana Panit Printing & Publishing Company Limited. Available: http://www.onec.go.th/HTML_99/ONEC_PUB/Book/YR42/ed_in_thailand99

Office of the National Education Commission (ONEC). (2000a). Learning Reform: A Learner-Centred Approach. Bangkok, Thailand: Wattana Panit Printing & Publishing Company Limited.

Office of the National Education Commission (ONEC). (2000b). National Education Act B.E. 2542 (1999). Bangkok: Office of the Prime Minister Kingdom of Thailand.

Pitiyanuwat, S. and Anantrasirichai, A. (2002). Curriculum and learning reform in Thailand. Paper presented at Invitational Curriculum Policy Seminar: School Based Curriculum Renewal for the Knowledge Society Developing Capacity for New Times, Hong Kong, 14 – 16 November 2002. Available: http://ci-lab.ied.edu.hk

Ratcliffe, M. (1995). Adolescent decision-making, by individuals and groups, about science-related societal issues. In Westford, G., Osborne, J., and Scott, P. (Eds.). (pp. 126 – 140). Research in Science Education in Europe: Current Issues and Themes. London, UK: The Falmer Press

Sengsook, R. (1997). A Study of Mathayomsuksa 1-6 Students’ Conceptions of Energy in Donchimpleepittayacom School, Amphoe Bangnumpeaw, Changwat Chachoengsao: a case study. Bangkok, Thailand: Thesis of Master Degree in Science Teaching, Kasetsart University.

Sinlarat, P. 1999. Alternative forms of in-service training in the redevelopment of teachers. Education Management and Financing in Thailand: Review and Recommendations Research Papers, Vol II. Bangkok, Thailand: UNESCO.

Solomon, J. (1985). Teaching the conservation of energy. Physics Education 113 – 114.

Titthummo, Jarun. (2004). The development of mind (Pattana Jitta). Available: http://www.jarun.org/42-10.htm

Yuenyong, C. 2006. Teaching and Learning about Energy: Using STS approach. Bangkok, Thailand: Thesis of Doctoral Degree in Science Education, Kasetsart University.

Yuenyong, C. and Narjaikaew, P. (2009). Scientific Literacy and Thailand Science Education. International Journal of Environmental and Science Education. 4(3): 335 – 349.

Yuenyong, C., Sung-ong, S., Veerapaspong, T. (2005) (in Thai) Thai and New Zealand Students’ Concepts about Energy and the Law of Energy Conservation. Kasetsart Journal: Social Science, 26(1): 42 – 51

Zohar, A., and Dori, Y. J. (2003). Higher order thinking skills and low-achieving students: are they mutually exclusive?. The Journal of the Learning Sciences, 12(2), 145 – 181.