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Scientific Literacy and Thailand Science Education

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Education and political leaders worldwide are increasingly placing emphasis on developing scientific literacy. This also is the case in Thailand with science education influenced by educational reform in 1999, in which the goals of science education are shaped by the notion of scientific literacy. Thai science education emphasizes the scientific knowledge, the nature of science, and the relationship between science technology and society. Although the school science curriculum features scientific literacy, Thai science education research, articles, national tests, and teaching and learning emphasize scientific achievement with little concern about science as a way of knowing. However, some attempts at developing scientific literacy have been made recently. Some school science curricula and teaching and learning has tried to organize science learning emphasizing the relationship between science, technology and society based on the Thai context. Such cases seek to develop students' scientific literacy through local wisdom; specifically, King Bhumibol Adulyadej's philosophy of sufficiency economy, moral infusion, and the Buddhism way of life. This paper considers interpretations of the term scientific literacy in Thailand, and examines the implications of this for science education.

Key Words: scientific literacy, moral, sufficiency economy, Buddhism

Introduction

It seems that citizens of most modern industrial countries live in a scientific and technological 'culture', in which daily living is significantly impacted upon by science (Miller, 1996). In an era of intense international economic competition, manufacturers also need scientifically capable staff - people who have good understanding of, and ability to do science. According to Thai authorities, learning of science and technology is important for all people in this economically competitive world (Office of the National Education Commission [ONEC], 2003).

There has been rapid expansion of the number of scientific and technological products that become increasingly part of everyday life. This, according to some authors means everyone needs to have some scientific literacy in order to make decisions and engage in debates about scientific issues (Tasakorn & Pongtabodee, 2005). The literature relating to the meaning

of, and rationales for scientific and technological literacy (STL) and scientific literacy (SL), suggest that it depends on culture and the values and advocacy of different interest groups. In other words, arguments for scientific literacy reflect the orientations and interests of those who seek to advance and realize scientific literacy (Boujaoude, 2002). However, there is some common ground. According to Osborne (2000) and Hodson (2003), scientific literacy can be perceived in four different ways including: (1) cultural: developing the capacity to read about and understand issues relating to science and technology in the media; (2) utilitarian: having the knowledge, skills and attitudes that are essential for a career as scientist, engineer or technician; (3) democratic: broadening knowledge and understanding of science to include the interface between science, technology and society; and (4) economic: formulating knowledge and skills that are essential to the economic growth and effective competition within the global market place.

A cultural view of scientific literacy is related to values, as when a person reads about and understands issues relating to science and technology in the media or society. The potential of science to inform and empower understanding and decision making by individuals, community activists, or other groups, is different. Jenkins (1990), however, argues that scientific literacy is not free value. Arguments for scientific literacy may not easily cross national or cultural boundaries. In other words, scientific literacy can only be understood by reference to the values that support science itself within a given society. A utilitarian view of scientific literacy is that of holding essential knowledge, skills and attitudes for a career. People who have scientific literacy thus may have better opportunities to engage in productive careers. The literature suggests that there are various frameworks that share common themes. Those frameworks could be addressed as following.

Scientific literacy may also be defined in terms of a framework consisting of four aspects: (1) the knowledge of science, (2) the investigative nature of science, (3) science as a way of thinking, and (4) interaction of science, technology and society (Boujaoude, 2002; Chiapetta, 1993).

Hurd (1998) suggested a definition of scientific literacy based on the seven dimensions of a scientifically-literate person. To:

- (1) Understand the nature of scientific knowledge;
- (2) Apply appropriate science concepts, principles, laws, and theories in interacting with his universe;
- (3) Use the process of science in solving problems, making decisions, and furthering his own understanding of the universe;
- (4) Interact with values that underlie science;
- (5) Understand and appreciate the joint enterprises of science and technology and the interrelationship of these with each and with other aspects of society;
- (6) Extend science education throughout his or her life;
- (7) Develop numerous manipulative skills associated with science and technology."

Bybee (1997) proposes a way of developing scientific literacy in learning biology as a continuum of understanding about the natural and the designed world. This starts from scientific illiteracy, moving to nominal, functional, conceptual and procedural, and multidimensional scientific literacy.

- (1) Scientific Illiteracy, the indicator of scientific illiteracy is the fact that they cannot relate to or respond to a reasonable question about science. They do not have the

- vocabulary, concepts, contexts, or cognitive capability to identify the question as scientific;
- (2) Nominal Scientific Literacy, the students understand the topic as scientific but the level of understanding clearly indicates a misconception;
 - (3) Function Scientific Literacy, students can memorize appropriate definitions of terms, and in this sense have some scientific knowledge, but they have limited knowledge and lack a full scientific understanding;
 - (4) Conceptual and Procedural Scientific Literacy, students actually have ability and understand that scientific inquiry includes asking questions, designing scientific investigations, using appropriate tools and techniques, developing explanations and model using evidence and explanation, recognizing alternative explanations and communicating scientific procedures and explanations;
 - (5) Multidimensional Scientific Literacy, students develop some understanding and appropriation of science and technology as they have been and are a part of the culture. Students begin to make connections within scientific disciplines, between science and technology and the larger issues of social challenges.

In a similar way, UNESCO (2001) describes scientific and technological literacy (STL) as mainly ‘internalist’ (i.e., related to activities within classrooms): 1. Nominal STL (i.e., recognizing science terms and concepts), 2. Functional STL (i.e., describing concepts with limited understanding) and 3. Structural STL (i.e., constructing concepts with personal relevance from experience and, 4. Multi-dimensional STL, equates with “empowering all students to lead productive lives”, “understanding the interactions between science and society” and a life-long ability “to ask and answer appropriate questions”, that is, it has indispensable societal and cultural aspects.

A democratic view of scientific literacy is that it enables citizens to become sufficiently aware of science-related public issues (such as health, energy, natural resources, food, and the environment). People, therefore, have to hold a broad knowledge and understanding of science - including the interface between science, technology and society. A scientifically-literate person should then be aware of science related public issues and be able to make decisions and hence improve the quality of his or her life. This is based on acquiring educational skills involving intellectual, attitudinal, communicative, societal and interdisciplinary learning (Holbrook & Rannikmae, 2001; Laugksch, 2000).

Some authors argue that scientific literacy is important for participation in democracy and political activities. Scientists, for example, may support the development of scientific literacy because it may help the public to understand science related societal issues and everyday phenomena and to provide the political support for the activities of scientists as well as provide opposition to those hostile to the scientific enterprise (e.g., animal rights activists and creation scientist - see Boujaoude, 2002). Jenkins (1990) gives a number of reasons as to why scientific literacy is important in a democratic system.

Public scientific literacy underpins the political support required both for the successful prosecution of science in a modern, industrialized democracy and for the ability of the scientific community to counter opposition e.g. from religious fundamentalists or animal rights groups. The achievements of science and technology and the dominance of ‘scientific rationality’ as an approach to solution of a wide range of problems suggest another way in which science itself might benefit from a more scientifically literate population (Jenkins, 1990, p. 45).

An economic view of scientific literacy relates to formulating knowledge and skills that are essential to the economic growth and effective competition within the global marketplace. In other words, scientific literacy is perceived as positive - relating to prosperity and creation of wealth. The PISA assessment is an example of nations examining public scientific literacy, to reflect ability of competition within a global economy.

Jenkins (1990) argues that scientific literacy depends on time and social contexts and on the primary purpose. For example, national scientific literacy enhances national economic prosperity or security. However, the integration of science within the economics of industrial societies as well as in the technologies of war and pollution causes certain concerns about the ethical nature of the scientific enterprise. An important aspect of scientific literacy, then, relates to defense of issues that have risen in the political arena, where the scientific community has often sought to defend itself against its critics.

Scientific literacy may provide benefits to individuals in a variety of ways. Scientifically literate citizens may take decisions on the basis of personal or economic well-being as Jenkins (1990) notes:

Scientifically literate citizens may have access to a greater range of employment opportunities and feel more confident in responding to the demands made by new technologies. They may be better able to evaluate 'scientific' evidence used in advertising or better equipped to take decisions about matters that affect their personal or economic well-being e.g. diet, medication, and safety energy usage (p. 45).

A key goal of Thai science education is to help students think by considering the relationship between science, technology and society. This goal needs people who are scientifically literate in order to address issues of science technology and society that affect Thai citizens (IPST, 2002). We argue here that Thai conceptions of scientific literacy may be different, and depends on Thai culture and values.

Conceptualization of Scientific Literacy in Thailand

As in other countries, international organizations and political leaders worldwide have influenced the conceptualization of scientific literacy in Thailand. Thai literature about scientific literacy or scientific and technological literacy shows that a Thai concept of scientific literacy is also related to international perceptions. Organizations such as UNESCO, ICASE, SEA-MEO-RECSAM and PISA activities, influence the issue of scientific literacy in Thailand.

Reviewing Thai literature about scientific literacy suggests that scientific literacy in Thailand is related to the application of scientific knowledge with respective social economic, technology, value and cultural surroundings; and desirable characteristics' of people who held basic scientific knowledge and skills. Key features of the Thai science education research literature are now discussed.

Sung-ong (1988) analyzed the causal relationship between student factors, school factors, home environment and each factor of scientific literacy of in elementary schools in Bangkok. She then developed a conceptual framework of scientific literacy that consisted of four aspects including basic knowledge of science, scientific process, and scientific inquiry.

Laohaphaibool (1992) argues that science teaching should not only provide pure science concepts, but also consider the relationship between science, technology and society. This way of science teaching could enhance students' scientific literacy, he suggests. To provide science teachers with ideas for teaching for scientific literacy, he produced a pyramid analog (Figure 1). Here an individual's intellectual development is a triangle that forms the base of a pyra-

mid. In order to form the pyramid, a triangle is placed at the base of pyramid, and requires three other triangles to make up scientific literacy. These three triangles include: (1) understanding of the environment, (2) thinking process and reasoning to investigate knowledge about those environment, and (3) scientific habits of mind.

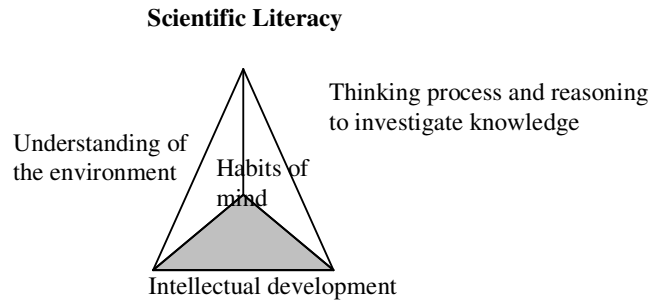


Figure 1. Analogy of scientific literacy according to Laohaphaibool (1992)

Kositichaiwat (1992) studied lower secondary students' scientific literacy in Bangkok. She defined scientific literacy as desirable characteristics' people held about basic scientific knowledge and skills and this consisted of 5 factors. These factors were: (1) understanding of nature of scientific knowledge; (2) understanding scientific concepts, laws, and principles; (3) skills for investigating knowledge; (4) scientific knowledge; and (5) awareness of the relationship between science and technology that influences to society.

Nuang-rit (1995) studied the outcomes of science teaching through a science, technology, and society (STS) approach. One of the outcomes identified was scientific literacy which she defined as people abilities in applying scientific knowledge and worldviews in their everyday life. She reported that science teachers have to organize learning activities in order to enhance students' scientific literacy and produce 'good' citizens.

Verawaiteeya (1996) tried to inform Thai science educators and teachers about the importance of scientific literacy. She argued that scientific literacy would be the new standard of science learning in the 21st century. Scientific literacy she sees as scientific knowledge and process skills at the level of application for surviving within the influence of society, economy and culture. People, who hold scientific knowledge and process skills, are able to explain phenomena and find reasonable solutions to various problems. Public understanding of science she argues supports people to understand and in decision making for their family, local and national issues based on scientific and technological conception.

Sawatmul (2002) carried out the Delphi study to investigate the conceptual framework of scientific literacy in Thailand. She reported that scientific literacy in the Thai context had been defined as a way in which a person can understand or comprehend all of the scientific knowledge, which could be applied appropriately in daily life. The application of the scientific knowledge has to be in accordance with the respective social, economic, and cultural surroundings. She drew experts' conclusion of scientific literacy in Thai context, arguing that we should be concerned with the following issues: (1) the understanding of the relationship between science and technology; (2) the knowledge and understanding of the impact of science and technology on society; (3) the recommendation that the scientific values and scientific attitudes should be included; (4) science process skills; (5) mathematics skills; (6) the application of science and technology in daily life; (7) the understanding of basic scientific know-

ledge and its limitations; (8) appreciation and awareness of the significance of science; (9) the use of scientific knowledge with the consideration of moral and ethical aspects; (10) the understanding of some natural phenomena which are related to human beings but inexplicable.

A number of international organizations (e.g., UNESCO, ICASE, SEAMEO-RECSAM, and OECD) are reported to have influenced the conceptualization of scientific literacy in Thailand. A world conference on education for all held at Jomtien, Thailand in 1990, suggested 'education for all' and 'science for all' in Thailand (and elsewhere). The recommendation of this conference influenced UNESCO and ICASE to launch *Project 2000+: Scientific and Technological Literacy For All* in 1993 (UNESCO, 2001). Project 2000+ promotes two important facets of teaching: (1) teaching through use of project work for developing of problem solving and communication skills; and (2) teaching relevant issues for developing decision making skills related to social issues where acquiring science and other knowledge. Many projects worldwide were subsequently launched within the framework of Project 2000+. Additionally, in order to enhance the capacity of teachers to cope with 'change' and to be more involved in bringing about a thorough infusion of the scientific and technological culture into society, there were many workshops held in Asia to develop teaching-learning materials in science and technology education relevant in the 21st century. Workshops were held in Lahore, Pakistan (1997), Manila, The Philippines (1997), Kathmandu, Nepal (1998), SEAMEO-RECSAM, Penang, Malaysia (1999), and Langkawi, Malaysia (2000). During those workshops, participants from member countries of the region attempted to develop exemplar materials based on the criteria proposed and educational objectives suggested for developing supplementary teaching-learning materials, for *Scientific and Technological Literacy for All*. Subsequently, a workshop of training of trainers for promoting scientific and technological literacy was launched in Bangkok, Thailand in 2001 as a collaborative project of the International Council of Associations for Science Education (ICASE), Southeast Asian Ministers of Education Organization Regional Centre for Education in Science and Mathematics (SEAMEO-RECSAM), and UNESCO Principal Regional Office for Asia and the Pacific (PROAP) (UNESCO, 2001).

Even though Thailand is not a member country of the OECD, it engaged in PISA in the hope that it would help develop the economy, along with other OECD member countries. PISA provides an indicator for the development of the economy based on science education. The notion of developing quality citizens through science learning related to everyday life, was increasingly driven by the Thai government who was interested to qualify for membership of the OECD. In order to do so, Thailand had to show that its people held scientific literacy at a similar level to that of OECD members. The OECD framework suggests that science should be taught starting from science about the earth and environment, science in life and health, and science in technology. This approach probably intends that science will be related to students' everyday life (The Manager, 2002). To drive increased performance in PISA and to enhance scientific literacy, IPST (2008) published articles about the significance of public understanding of science on its website. This stated that if all Thai people are scientifically literate, they will gain in terms of their quality of life and Thai society as a whole will benefit. Science literacy is described by IPST as process of surviving in everyday life, so that people can understand scientific information and issues related to science for their lives and society. According to IPST, people who possess scientific literacy are able to: (1) perceive questions and problems that could be verified through scientific method; (2) identify evidences or data for inquiring; (3) give reasonable explanation related to empirical data or evidences; (4) communicate or explain conclusion of issues related to science to others; and (5) understand the principle and scientific concepts (IPST, 2002).

The vision and goal of Thailand science education not only, conceptualizes scientific literacy, but considers the impact this should have on school science teaching. To realize the vision proposed in the reforms, the science curriculum should be relevant to learners' real life experience. In Thailand, science is a compulsory topic in the Thai high school curriculum from Grades 1 - 12. The National Education Plan 1997, Section 9, emphasizes science and technology, and is based on the principle that all learners are capable of learning and self-development. The Institute for the Promotion of Teaching Science and Technology (IPST) (2002) stipulates the goals of science education for scientific literacy to be the following:

- understand the principles and theories of scientific knowledge;
- understand the scope, limitation and the nature of science;
- engage in science process skills, scientific inquiry, and investigation in science and technology;
- develop thinking skills and the capability for problem solving, and communication skills and decision making;
- be aware of interrelationship between science, technology, society, humans and the environment;
- apply science and technology for the survival of the society; and
- be aware of the habits of mind, ethics, morals, and values in science and technology.

In summary a common view of scientific literacy in Thailand, is that of a person: (1) who holds understanding of scientific knowledge and the relationship between science, technology, society, and environment; (2) engages in thinking process and reasoning to investigate knowledge; (3) possesses scientific habits of mind for living.

Teaching Approach for Developing Scientific Literacy in Thailand

The science and technology curriculum for primary, secondary, and tertiary education in Thailand outlines what students have to know and be able to do in science, and provides teaching programs and assessment policies. One implication to arise from the examination of these documents is that science education must aim to enhance students' capability and interest in science, and a desire to search for knowledge so that they can learn continually at any time and any place throughout their lives (Office of the National Education Commission [ONEC], 2003). According to the vision, there are some ways of developing scientific literacy that should be addressed. For example, school science curricula and teaching and learning attempt to organize science learning that emphasizes the relationship between science, technology and society - based on a Thai context. This science, technology, and society (STS) approach, also draws upon local wisdom, specifically the King Bhumibol Adulyadej's philosophy of sufficiency economy, moral infusion and a Buddhism-based way of life. This paper reviews this unique interpretation of the term scientific literacy in a Thai context, and examines' their implications for science education in Thailand.

There has been some Thai research done that examines students' awareness of the interaction between science, technology and society in order to develop scientific literacy. For example, Yuenyong, Jones and Yutakom (2008) examined Thai students' values and norms in terms of the interaction between science, technology and society through a comparison between Thai and New Zealand students' ideas of energy. It seems student ideas are generated by engaging with issues in different contexts, with for instance Thai students placing value on decision-

making about the development of energy production in the country. They strongly believed in a scientific application for solving social problems, and Thai students see particular value in the use of experts (e.g. scientists or engineers) in decision-making about issues related to science, technology, and society - rather than taking cognizance of the public's view.

In order to enhance science teaching through an STS approach in Thailand, Portjanatanti (2003) and Yuenyong (2006) attempted to develop science teachers' knowledge of STS approach. Portjanatanti (2003) developed biology pre-service teachers' understanding of biology teaching through an STS approach. The teachers involved were subsequently able to develop lesson plans based on this STS approach and came to realize the interactions among science, technology, and society and valued science and technology in terms of life survival factors. Likewise, Yuenyong (2006) used an STS approach to teach energy in a process that consisted of five stages: (1) identification of social issues, (2) identification of potential solutions, (3) need for knowledge, (4) decision-making, and (5) socialization stage. Findings suggest that energy teaching and learning via STS enhanced students' understanding of energy concepts and also gave students a chance to develop their thinking skills, decision-making about energy-related technological and societal issues, and gained in terms of affective learning.

Other literature points to some movement towards the teaching science through an STS approach in Thai schools. STS units seem to enhance students' scientific literacy by developing various skills and perspectives related to STS issues. These skills include social responsibility; thinking and decision making skills; perception of the relationship between science, technology, and society; knowledge, skills and confidence to express opinions and take responsible action to address issues; and motivation toward science.

A number of studies based at the prestigious Kasetsart University in Bangkok point to enhanced performance of science teaching through an STS approach. This local research suggests that this approach enhances students' understanding of scientific concepts, and enhances their scientific attitude, thinking skills, and perceptions of science related to their daily life. This is now a key aspect of the teacher education program at KU. Almost all classes in the School of Education now develop STS units in workshops that are based on the Constructivism Learning Model (CLM) (Sakdiyakorn, 1998). The education about science teaching through an STS approach is now deeply embedded in primary and lower secondary level education at KU, and is the subject of on-going research. Sakdiyakorn (1998), Thewphaingam (1998), Jirasatit (1999), and Attachoo (2001), for example, studied the development of teaching strategies, and learning outcomes for science teaching through an STS approach derived from constructivism. Their research examined students' thinking skills and understanding of scientific concepts, and perceptions of how science is related to everyday life. In other work Jirasatit (1999) reports gains in understanding of scientific concepts and science skills for Grade 1 students, Thewphaingam (1998) likewise for Grade 2 students, Sakdiyakorn (1998) for and Attachoo (2001) for Grade 7 students' scientific concepts and skills, creative thinking, and attitude toward science. So local research based on the development and implementation of teacher education programs at KU seem to lead to positive gains at a variety of grade levels and across important variables such as conceptual understanding, positive attitude towards science and relating science to everyday life.

STS education for similar goals as Kasetsart University also is practiced now in other parts of Thailand and a lot of research has recently been conducted (see, Nuang-rit, 1995; Tothaiya, 1997; Chotethaisong, 1998; Jirasuksa, 2001; Kaewphonpek, 2001; Jetch, Portjanatanti & Churngchow, 2006). As an example of this other research Nuang-rit (1995) reports enhanced scientific literacy in Phanakornsri Ayuthaya province, central of Thailand for Grade 10 students' in terms of scientific investigation skills, understanding of the nature of science, and awareness of the relationship between science, technology and society from teaching through

STS approach. Likewise, Chotethaisong's (1998) adapted Yager's (1996) idea of STS for teaching pollution in Grade 11, in Khon Kaen province, in the northeastern part of Thailand. Her research suggests that students who learn science through an STS approach had higher learning achievement and more positive attitude towards learning about pollution than students who learn via a conventional approach. Similar work is reported by Kaewphonpek (2001) in Waengyaiwittayakom School, Khon Kaen, and Tothaiya (1997) at Phusingprachasermit School, Srisaket, in the northeast of Thailand, Jirasuksa (2001) at Yothinburana School, Bangkok, and Jetch et al. (2006) at Ban Krasoh School, Pattani, southern of Thailand. In summary there now is a substantial base of research in Thailand on the value of STS in teacher education that subsequently leads to enhanced student conceptual understanding and attitude towards science.

STS and Scientific Decision Making

The other main focus of STS education in Thailand is in the area of decision-making, and again there is now a substantial body of research based in Thailand. For example, Posri (2007) studied Grade 6 students' learning achievement about substances in everyday life and their decision making after science teaching and learning through an STS approach in Ban Khumkreung School, Khon Kaen, Thailand. It seems that teaching and learning about substances in everyday life through an STS approach raised student awareness of issues to do with health and nutrition. After an intervention, students could relate their experiences in society to science by, for example, seeing how local foods were preserved using local ingredients.

Students' technological capability is another aspect of scientific literacy studied in Thailand. Klahan and Yuenyong (2008) and Klahan, Boonkuang, and Yuenyong (2008) report enhanced technological capabilities for primary and secondary students about electromagnetics and problems with garbage. Students could incorporate scientific concepts into their models along with economics, the law, and art.

STS and Local Wisdom in Thailand – Towards A Sufficiency Economy

Local wisdom also is taken into account in Thai science teaching and learning. Local people may learn science based on the environment; climate, ecosystem, but also the influence of religion, culture, and ethnicity influence the local way of life. Local wisdom has developed as part of the development of local people. Integrating local wisdom to the class may allow the learner to proudly display his or her conceptual knowledge (Na thalang, 2001). Learning science based on local wisdom may enhance students' ability to investigate and explain scientific knowledge behind that local wisdom. Pangvong (2007), for example, developed a science learning unit using local wisdom through STS approach. Her unit allowed students to learn science from local learning resources, cultural activities, local values, and by sharing knowledge with village scholars who shaped scientific ideas from their experiences and knowledge transmission from ancestors. Pangvong (2007) integrated local wisdom into her learning unit about soil and its problems as illustrated in Table 1.

Presently, King Bhumibol Adulyadej's philosophy of sufficiency economy is very important in Thailand. From the king's perspective, all fields of research can apply this philosophy. In the field of education, providing citizens, who hold the philosophy of sufficiency economy (PSE) as the way of their life or working, is a crucial goal. The PSE stresses the Buddhist principle of the "middle path" as a guiding principle for people at all levels of their livelihood. The philosophy of a sufficiency economy includes three elements: moderation, reasonable-

ness, and self-immunity, and requires two conditions for the philosophy to work: knowledge and virtues. The Figure 2 sums up the philosophy (UNDP, 2007).

Integrating PSE in science teaching and learning may support students to learn science through ethical decision making, and helps them engage in considering the relationship between science, technology and society. The integration of PSE in science education seeks to produce a scientifically literate person, based on Thai values. Yuenyong (2009) reports enhancing science teachers' capability to teach science by considering the nature of science, and the relationship between science, technology and society through an STS approach based on the philosophy of a sufficiency economy. Participating teachers taught physics through an STS approach in order to support their students to make decision based on the philosophy of a sufficiency economy. This research suggested that students' decision making based on PSE enhanced their self-immunity, and desirable characteristics of living in society of science and technology.

The relationship between science and values surfaces in Thailand science education by virtue of the impact of a Buddhism-based way of life, which is infused in science teaching and learning. This approach also may impact upon students' scientific literacy as reported by Prayutho (1991). Thai Buddhist Way Schools aim to enhance students life long learning; excellence in ethic, moral, academic, and sport; social responsibilities; and respect of religion, culture, tradition, and virtue. To obtain such school goals, students have to be successful in six areas: duty, devotion, discipline, discrimination, and determination. In order to introduce students' to the Buddhist way of life, early morning all students have to read Buddhist scriptures and engage in Buddhist Meditation for Peace. In the first period of Thai Buddhist Way Schools, students have to learn the subject of human merit that emphasizes five aspects of human merit: love, mercy, truth, good conduct, peace, and non-oppression. Science subjects have to integrate with religion, tradition, culture, and local wisdom. For example, when learning about fluids and buoyancy, students have to integrate other subjects via the theme of "Loy Kratong". Loy Krathong is held on the full moon of the 12th month in the traditional Thai lunar calendar. In the western calendar this usually falls in November. Loy" means "to float". "Kratong" is a raft about a handspan in diameter traditionally made from a section of banana tree trunk. However, now, Krathong use specially made bread 'flowers' and may use styrafoam and other materials, decorated with elaborately-folded banana leaves, flowers, candles, incense sticks and so on. During the night of the full moon, many people release a small raft like this on a river. Governmental offices, corporations and other organizations also build much

Table 1. Science content of soil and its problem, and local wisdom

Science content	Local wisdom for STS unit
Soil properties	Local wisdom about collecting soil specimen and characteristics
Living thing and organic matter in soil	Local wisdom about earthworm versus monster
Soil problems	Local wisdom about finding solutions of acid and alkaline soil
Fertilizer	Local wisdom of using soil from the bottom of the pond and buffalo quagmire as fertilizer
Land management	Local wisdom about agriculture in 1 Rai (1,600 square meters or 0.4 acre)
Organic agriculture	Local wisdom of organic agriculture

bigger and more elaborate rafts, and these are often judged in contests. Learning science in Loy kratong tradition allowed students to contest and do experiment about floating and sinking, and buoying force (Satayasai School, 2007).

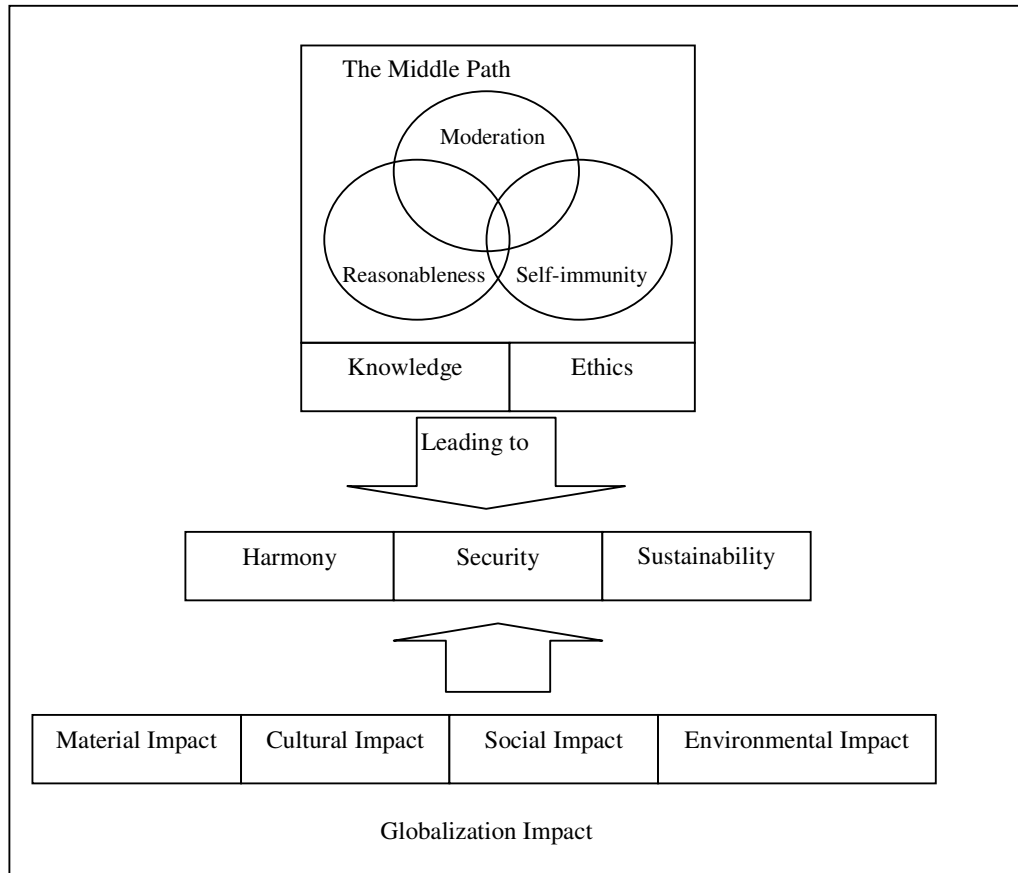


Figure 2. The philosophy of a sufficiency economy (UNDP, 2007)

Current Status of Scientific Literacy in Thailand

Although the Thai school science curriculum features scientific literacy, and many schools use an STS approach to teaching, it seems that the normal situation is that science teaching in Thailand emphasizes scientific achievement, rather than learning science for everyday life. The value of Thailand science education is still interpreted in economic terms (Dahsah & Fakama, 2008), and science and mathematics education are seen as key economic enablers in a competitive world. To respond to the needs of the country, academic institutions are oriented to provide human resources, specializing in science and technology rather than being concerned with the public understanding of science. Thai science education research, articles, national tests, and thus teaching and learning of science emphasize scientific achievement. Popular and prestigious schools in particular, strongly emphasize science achievement, providing special programs in science and technology. Students who are identified as the gifted

and talented in science and mathematics are selected to attend special educational programs in order to enhance their achievement in science. Many students from such schools are selected to be candidates in International Science Olympiads.

The result of the PISA assessment is something of a reflection of the Thailand science education system, and its lack of ability to enhance science literacy. In 2006, Thai students scored an average of 421 points, lower than the OECD average by a whopping 79 score points (IPST, 2007). Thai students' performance was in the bottom quarter, and overall Thai students' average score was at the basic level (level 2). Approximately 46 % of Thai students' understanding in science was lower than level 2, meaning that Thai students only have adequate scientific knowledge to explain simple investigations.

Hence, in Thailand thinking about science education in general, and scientific literacy in particular, is influenced by the OECD economic rankings as well as PISA. The feeling in the nation nowadays is that there is an urgent need for more trained science teachers. An example of how the nation has responded to poor performance in OECD and PISA rankings is the IPST's research project about teaching science to talented primary students. This project was driven by the particularly poor performance of Thai primary students' in PISA. It consists of a teacher training program that aims to provide teachers who are capable of producing students with the ability to engage in critical thinking in science and learn science related to everyday life.

Conclusions

The meaning of the term scientific literacy in Thailand has been influenced by international organizations and assessment activities, along with economic development, and the views of political leaders. A key notion is that of providing Thai citizens with education that will help them and the nation or survive in a globally competitive economy. The conceptualization of scientific literacy in Thailand is thus that recognized by IPST, and other educational organizations and researchers, who have determined that the aims of science education are in the application of scientific knowledge with respect to social, economic, technology, and culture surroundings.

The status of scientific literacy in Thailand could be considered through the notion of learners' habits of mind where students' values, attitudes, and skills are related to their views about knowledge and learning, and ways of thinking and acting. The AAAS (2006) recommends that habits of mind could be viewed as values, attitudes, and skills that are influential in shaping people's views of knowledge, learning, and other aspects of life. Aspects of values and attitudes include the values inherent in science, mathematics, and technology; the social value of science and technology; the reinforcement of general social values; and people's attitudes toward their own ability to understand science and mathematics. Skills related to computation and estimation, to manipulation and observation, to communication, and to critical response to arguments.

The local research that has been done in Thailand seems to indicate that scientific literacy in Thailand could be developed by teaching science through an STS approach, incorporating the infusion of local wisdom into science learning, and applying the Philosophy of a Sufficiency Economy. These approaches provide for science learning and the application scientific knowledge that is relevant to the social, economic, technology needs of the nation, whilst balancing values with a Buddhist view, which is of considerable importance to the local way of life. It is noted, however, that such an approach is somewhat disconnected with the current political drivers of science education - as an enabler of economic development. In order to

find solutions for the proposed issues in their class, students would develop thinking process and reasoning to investigate knowledge. Scientific habits of mind (e.g. rationality, argument and curiosity) would be acted when students negotiate to reach decisions about various issues.

References

- American Association for the Advancement of Science (2006). *Habits of mind*. Retrieved 18 December 2006, from <http://www.project2061.org/publications/rsl/online/SFAA/CHAP12.HTM>
- Attachoo, P. (2001). Research report of classroom research: Science teaching through science, technology and society/constructivism for grade 7 students. *IPST Journal*, 30(115), 29-35.
- Boujaoude, S. (2002). Balance of scientific literacy themes in science curricula: The case of Lebanon. *International Journal Science Education*, 24(2), 139-156.
- Bybee, R.W. (1997). *Achieving scientific literacy*. Portsmouth, NH: Heinemann.
- Chiapetta, E.L. (1993). Do middle school life science textbooks provide a balance of scientific literacy themes? *Journal of Research in Science Education*, 30(7), 787-797.
- Chotethaisong, C. (1998). *A comparative study of learning achieving and attitudes towards pollution of mathayomsuksa V (Grade 11) students between science-technology and society (STS) approach and the conventional approach*. Unpublished masters of education thesis, Khon Kaen University.
- Dahsah, C., & Faikhamta, C. (2008). Science education in Thailand: Science curriculum reform in transition. In R.K. Coll & N. Taylor. (Eds.), *Science education in context: An international examination of the influence of context on science curricula development and implementation* (pp. 291-300). Rotterdam: Sense.
- Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education*, 25(6), 645-670.
- Holbrook, J., & Rannikmae, M. (2001). *Introducing STL: A philosophy and teaching approach for science education*. London: International Council of Associations for Science Education.
- Hurd, P. (1998). Science literacy: New minds for a changing world. *Science Education*, 82(3), 407-416.
- Institute for the Promotion of Teaching Science and Technology (2002). *The Manual of content of science learning*. Bangkok: Curusaphaladphoa.
- Institute for the Promotion of Teaching Science and Technology (2007). *Programme for international student assessment OECD/PISA*. Retrieved 18 Aril 2009, from http://www.ipst.ac.th/eval_standard/pisa/executive%20sum_Tha_for%20web2.pdf [in Thai].
- Institute for the Promotion of Teaching Science and Technology. (2008). *National science curriculum standards: The basic education curriculum B.E.2544*. Retrieved 14 May 2008, from <http://kroo.ipst.ac.th/ipst/eng/curriculum/ScienceCurriculum.pdf>
- Jenkins, E. (1990). Scientific literacy and school science education. *School Science Review*, 71(256), 43-51.
- Jeteh, A., Portjanatanti, N., & Churngchow, C. (2006). Effects of learning unit on food and nutrient through science, technology and society approach of mathayomsuksa three students in basic educational extending opportunity school. *Journal of Education, Prince of Songkla University*, 17(2), 184-199.
- Jirasatit, S. (1999). *Research report of result of science teaching through science, technology and society / constructivism for grade 1 students*. Bangkok: Laboratory School of Kasetsart University.
- Jirasuksa, N. (2001). *The study of grade 10 students' chemistry learning achievement about substance and its change through science, technology, and society approach*. Unpublished masters of education thesis, Srinakharinwirot University.
- Kaewphonpek, B. (2001). *The effects of science camp activities using science, technology and society on the development of problem solving skills and attitudes toward science of mathayom suksa IV (Grade 10) students at Waengyaiwittayakom school in Khon Kaen province*. Unpublished masters of education thesis, Sukhothai Thamathirat Open University.

- Klahan, P. Boonkuang, A., & Yuenyong, C. (2008, January). *Primary 5 students' technological capabilities in teaching and learning about materials through science technology and society (STS) approach*. Paper presented at Curtin University of Technology Fifth International Conference on Science, Mathematics and Technology Education: Science, Mathematics and Technology Education Beyond Cultural Boundaries. Rajabhat Udontani University.
- Klahan, T., & Yuenyong, C. (2008, November). *An analysis of secondary 6 students' technological capability through teaching and learning about electromagnetics on science technology and society approach (STS Approach)*. Paper presented at Asia-Pacific Educational Research Association, National Institute of Education, Singapore.
- Kositchaiwat, S. (1992). *Scientific literacy of students in lower secondary school, group of school under the auspices of General Education Department, Bangkok Metropolis, Group 2*. Unpublished masters of education thesis, Kasetsart University.
- Laohaphaibool, P. (1992). *Science teaching in secondary science classroom*. Bangkok: Thaiwattanapanit.
- Laugsch, R.C. (2000). Scientific literacy: A conceptual overview. *Science Education*, 84(10), 71-94.
- Miller, J.D. (1996). Scientific literacy for effective citizenship. In R.E. Yager (Ed.), *Science/technology/society as reform in science education*. New York: State University of New York Press.
- Nathalang, A. (2001). Concept of education and transmit of local wisdom. *Journal of Curasart*, 27(2), 1-21.
- Nuangrit, C. (1995). *A comparison of the science-technology-society based learning outcomes as attained by mathayom suksa IV (Grade 10) students through the modified science-technology-society approach and the IPST' s approach*. Unpublished masters of education thesis, Srinakharinwirot University.
- Osborne, J. (2000). Science for citizenship. In M. Monk & J. Osborne (Eds.), *Good practice in science teaching* (pp. 225-240). UK: Open University Press.
- Office of the National Education Commission. (2003). *Synopsis of the National Scheme of Education of B.E. 2545-2559 (2002-2016)* (2nd ed.). Bangkok: Office of the National Education Commission.
- Pangvong, C. (2007). *The outcomes of science learning activities using local wisdom based on science technology and society (STS) approach*. Unpublished masters of education thesis, Khon Kaen University.
- Portjanatanti, N. (2003). *The instruction of teaching of biology course using science, technology and society*. Unpublished PhD thesis, Kasetsart University.
- Posri, P. (2007). *Grade 6 students' scientific achievement and decision making ability based on science technology and society (STS) approach*. Unpublished masters of science education thesis, Khon Kaen University.
- Prayutho, (1991, August). *Buddhism as science*. Keynote paper presented the Thailand Science Day, Faculty of Science, Chiangmai University, Thailand. Retrieved 8 December, 2009, from <http://www.dharma-gateway.com/monk/preach/lp-prayuth/lp-prayuth-22-01.htm>
- Sakdiyakorn, M. (1998). *Research report of classroom research: Science teaching through science, technology and society/constructivism for grade 3 students*. Bangkok: Laboratory School of Kasetsart University.
- Satayasai School (2007). *Handbook of Satayasai school*. Unpublished book: Suphanburi, Thailand.
- Sawatmul, S. (2002). *A study of the characteristics of scientific literacy*. Unpublished masters of education thesis, Khon Kaen University.
- Sung-ong, S. (1988). *An analysis of causal relationship between students' factor, school' factors, home environment and each factor of scientific literacy of prathom suksa six students in elementary schools under the jurisdiction of the Bangkok metropolitan administration*. Unpublished PhD thesis, Chulalongkron University.
- Tasakorn, P., & Pongtabodee, S. (2005). *Research report: Science and technology curriculum for primary, secondary, and ternary education in Thailand*. Bangkok: The Secretarial of the Senate.

- The Manager. (2002, May 19) *Thinking about world class science education*. The Manager, p. 6.
- Thewphaingam, A. (1998). *Research report of classroom research: Science teaching through science, technology and society / constructivism for grade 2 students*. Bangkok: Laboratory School of Kasetsart University.
- Tothaiya, R. (1997). *Grade 3 students' learning achievement and ability of scientific problem solving from teaching through science, technology and society approach*. Unpublished masters of education thesis, Chiangmai University.
- United Nations Development Programme. (2007) *Thailand human development report 2007: Sufficiency economy and human development*. UNDP: Bangkok.
- United Nations Educational Scientific and Cultural Organisation. (2001). *The training of trainers manual for promoting scientific and technological literacy for all*. Bangkok: UNESCO.
- Veerawaiteeya, Y. (1996). Standard of science learning in the 21st century. *Journal of Education, Kasetsart University*, 11(3), 51-23.
- Yager, R.E. (Ed.). (1996). *Science, technology, society as reform in science education*. New York: State University of New York Press.
- Yuenyong, C. (2006). *Teaching and learning about energy: Using STS approach*. Unpublished PhD thesis, Kasetsart University.
- Yuenyong, C., Jones, A., & Yutakom, N. (2008). A comparison of Thailand and New Zealand students' ideas about energy related to technological and societal issues. *International Journal of Science and Mathematics Education*, 6(2), 293-311.
- Yuenyong (2009, in press). Developing pedagogical content knowledge in physics teachers applying the philosophy of sufficiency economy for physics teaching and learning through Science, technology, and society (STS) approach. *Journal of Khon Kaen University*.

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