



The development of a science, technology and society phenomenon-based learning model for promoting grade 12 students' problem-solving in geohazard

Prom Pookduang¹

Khajornsak Buaraphan²



(Corresponding Author)

¹Prasatwittayakarn School, Prasat District, Surin Province 32140, Thailand.

Email: prom.pookduang@gmail.com

²Institute for Innovative Learning, Mahidol University 999 Salaya, Phuttamonthon, Nakhon Pathom 73170, Thailand.

Email: khajornsak.bua@mahidol.ac.th

Abstract

This research aimed to: a) synthesize the Science, Technology, and Society Phenomenon-based Learning Model (STS-PhBL) for teaching Geohazard to students; and b) compare students' problem-solving skills prior to and after the STS-PhBL lessons on the Geohazard topic. The sample consisted of 39 Grade 12 students enrolled in the first semester of the 2021 academic year at one secondary school in Surin Province, Thailand. The data collection methods included the panel of experts' evaluation of STS-PhBL lesson plans and the Problem-Solving Skills Test. The Index of Item-Objective-Congruence (IOC) of STS-PhBL lesson plans on Geohazard was calculated. Also, the students' problem-solving skills prior to and after the STS-PhBL lessons in the Geohazard topic were analyzed by using the paired-samples t-test. The researchers synthesized a new STS-PhBL model from the intensive literature review, consisting of seven teaching steps: a) stimulate the phenomenon; b) identify problems in the phenomenon; c) explore the answer to the targeted problem; d) construct new knowledge; e) reflect on learning; f) exchange and share learning; and g) apply knowledge. The STS-PhBL lesson plans on Geohazard met the IOC requirements. After learning STS-PhBL lessons, the students significantly improved their problem-solving skills at the 0.05 statistically significant level.

Keywords: Geohazard, Phenomenon-based learning, Problem solving skills, Science, Technology and society.

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Contribution of this paper to the literature

This paper presents the Science, Technology, and Society Phenomenon-based Learning Model (STS-PhBL), an innovative teaching model for Geohazard in Grade 12. The STS-PhBL teaching steps are as follows: a) stimulate phenomena; b) identify problems; c) explore; d) construct new knowledge; e) reflect; f) exchange and share; and g) apply.

1. Introduction

In Thailand, the perception of teachers as a pillar of educational reform is common. To become a professional teacher, one must possess and develop several abilities, including teaching and learning management. Professional teachers should be well-equipped to put their pedagogy into practice by translating lesson plans into classroom actions. Good curriculum and pedagogy are expected to subsequently lead to good learning results (Chitchayawanich, 2019). In the 21st century, learners are expected to attain higher-quality attributes than in the past. Teaching in the 21st century should foster learners' self-knowledge and abilities to extract and analyze derived information for use in their daily lives, such as solving related problems in the real world (Vejjalak, 2018).

Problem-solving skills are one of the other essential skills for learners in the 21st century. Regarding this, students with problem-solving skills are expected to be able to apply their thinking process to solving real-life problems. Learners must develop problem-solving skills as an essential skill for their future careers and personal applications. One addition is that students should be promoted to work collaboratively with their classmates during their problem-solving tasks. Through collaborative problem solving, students can develop teamwork skills and exchange knowledge and experiences, among other things (Nuangchalerm, 2015). In any problem-solving task, a problem is regarded as the crucial part because it can motivate students to become suspicious and want to seek more new knowledge to solve such a targeted problem (Tisana, 2018). Teachers should incorporate situations or phenomena familiar to learners into the development of their problem-solving skills. In addition, at the end of the learning process, students should have the opportunity to assess their learning through self-assessment (Ngamchom, 2016).

People widely regard Science, Technology, and Society (STS) as one pedagogical approach to managing science teaching and learning. STS is based on constructivism that genuinely emphasizes learner-centeredness. Many countries, including Thailand, align STS with the direction of the education reform movement. The interactions among science, technology, and society can encourage students to realize the complexity of problems in the 21st century world, which demands higher problem-solving abilities. Additionally, STS provides students with an increased opportunity to view science from a variety of perspectives, including technological and societal ones. Students who learn with the STS approach will experience science through their interest in technological and societal perspectives. They will have more opportunities to play their roles as savvy citizens or country citizens (Pitipornatapin, 2015).

Phenomenon-based learning (PhBL) is another pedagogical approach emphasizing student-centeredness. PhBL is a multidisciplinary, constructivist form of pedagogy where students have the chance to explore several real-world phenomena by using various discovery methods (Bureau of Academic Affairs and Education, 2019). PhBL promotes student active learning by nature. PhBL encourages students to explore real-world phenomena, aiming to enhance their comprehension. Students express their interest in the targeted phenomenon and actively seek out additional information and understanding. Students take an active role in learning as creators of learning, using a variety of methods, resources, and tools in real-world situations (Butkatunyoo, 2018).

According to Silander (2015) there are five components of PhBL, that is, a) Holisticity - is a multidisciplinary learning that focuses on exploring through systematic experience with an understanding of the current situation; b) Authenticity - is the use of methods, tools, or materials needed in real-world situations to solve interest issues; c) Contextuality - is meaningful learning in various settings and contexts; d) Problem-based inquiry - is a learning process that engages students to set questions and explore by themselves until finishing their own learning process; and e) Learning process - is a process aimed to develop hypotheses and theories and makes a prediction about a particular phenomenon. In PhBL, students will be able to plan their learning process and use various tools to create their own learning. Furthermore, Butkatunyoo (2018) proposed three components of PhBL, collectively referred to as PEE. P (Plan): Teachers plan teaching and learning, beginning with the selection of content and the identification of learning standards and indicators that align with the targeted curriculum. (Execution): Teachers execute the plan by encouraging students to explore the phenomenon and gain a deeper understanding of it, using a range of information from relevant literature and data collection methods. E (Evaluation): Teachers assess students during learning, reflecting individual development through a variety of assessment methods such as self-assessment, teacher-assessment, and parent-assessment, with a focus on students' construction of knowledge.

One essential knowledge for teachers according to the conceptual framework of teacher professional development is technological knowledge; it means teachers' ability to apply technological tools and media in teaching the targeted topic. To promote effective teaching in science, science teachers must develop their knowledge and ability to integrate technology in their teaching and learning management appropriately in order to bring students to meet the goals of science education, emphasizing students to attain necessary scientific knowledge and apply scientific knowledge to 21st century phenomena (Thamprateep, 2016). This study, based on this rationale, aimed to develop the Science, Technology, and Society Phenomenon-based Learning Model (STS-PhBL) for teaching Geohazard to grade 12 students and investigate its effect on grade 12 students' problem-solving skills. The research objectives of this study were: a) to synthesize the STS-PhBL model and create its associate lesson plans for teaching Geohazard to grade 12 students; and b) to compare students' problem-solving skills prior to and after the STS-PhBL lessons on the Geohazard topic. These objectives guided the formulation of the research questions.

RQ1: What are the desirable teaching steps of the Science, Technology, and Society Phenomenon-based Learning Model (STS-PhBL)?

RQ2: Does the STS-PhBL affect grade 12 students' problem-solving skills on the Geohazard topic?

2. Research Methodology

This study employed two loops of Research and Development (R&D). In R1D1, the researchers employed documentary research (Scott & Marshall, 2015) and content analysis to analyze and synthesize the Science, Technology, and Society Phenomenon-based Learning Model (STS-PhBL). Then, the researchers used findings from R1 to develop the STS-PhBL model and associated six lesson plans for teaching Geohazard to grade 12 students. The lesson plans took a total of 12 hours to teach. The geohazard topic from the Earth, Astronomy, and Space subject served as the content for the STS-PhBL test, adhering to the subject matter and learning standards of the Basic Education Core Curriculum B.E. 2551 (2017) in Thailand.

2.1. Data Collection and Analysis

A panel of five experts with expertise in science and technology education received the STS-PhBL model and associated lesson plans for content validation. The experts were asked to give one of these scores (i.e., +1, 0, and -1) for each item statement dealing with the content validity of the STS-PhBL model and lesson plans. Regarding this, score 1 means the model or lesson plan corresponds with the targeted objective, while 0 and -1 mean unsure and do not correspond, respectively. After obtaining responses from experts, the researchers calculated the STS-PhBL model's Index of Item-Objective-Congruence (IOC) and lesson plans. In R2D2, the researchers aimed to examine the effects of the STS-PhBL model on grade 12 students' problem-solving skills. The findings from R2 were then used to revise the STS-PhBL model and lesson plans to be more complete.

2.2. Population and Sample

R2 consisted of 205 grade 12 students from six science classrooms enrolled in the first semester of the 2021 academic year at one secondary school in Surin Province, Thailand. The sample of R2 was 39 grade 12 students, who came from Cluster Random Sampling by using the classroom as a unit of sampling. These students were asked to take a pre-test and post-test of their problem-solving skills in the Geohazard topic, which consisted of 20 items. The students' problem-solving skills scores from the pre-test and post-test were compared and analyzed by a paired samples *t*-test.

3. Results and Discussion

The researchers analyzed six documents (Jitauafua, 2014; Luergam, 2009; Sengdala, 2013; Songkathee, 2017; Sutham, 2015; Tathin, 2015) from the literature related to STS by using content analysis, and the result is shown in Table 1.

Table 1. Summary of STS-PhBL teaching steps.

Luergam (2009)	Sengdala (2013)	Jitauafua (2014)	Tathin (2015)	Sutham (2015)	Songkathee (2017)	Summary of STS-PhBL
-	Identify social issue	Arousing interest	Bring social problems in classroom	Be curious	Identify social issue	Stimulate with the phenomenon
Search	Find possible solution	-	Find possible solution	Plan	Find possible solution	Identify problems in the phenomenon
Solve problem	Need to knowledge	Search	-	Search for solution	Need more knowledge	Explore answer of the targeted problem
Create knowledge	Decision making	-	Make decision	-	Make decision	Construct new knowledge
-	-	-	-	Reflect	-	Reflect learning
Exchange experience	Create social process	Present and explain findings	Exchange experience	Exchange experience	Create social process	Exchange and share learning
Apply	-	Apply	Apply	Apply	-	Apply knowledge

The analysis yielded seven common teaching steps of the STS-PhBL model for teaching the Geohazard topic to grade 12 students: The steps include: a) stimulating the phenomenon; b) identifying problems in the phenomenon; c) exploring the answer to the targeted problem; d) constructing new knowledge; e) reflecting on learning; f) exchanging and sharing learning; and g) applying the knowledge gained. The STS-PhBL model describes each teaching step as follows:

3.1. Step 1: Stimulate with the Phenomenon

A teacher stimulates students' interest and makes them eager to learn by presenting the phenomenon that is ingested and linked with their daily lives. The assigned curriculum should incorporate specific scientific content that connects with societal and technological viewpoints, forming the core of STS-PhBL. Teachers should use pre-tests or other appropriate methods to explore students' prior knowledge before teaching them the new concept.

3.2. Step 2: Identify Problems in the Phenomenon

Students gather in group of four to six members with mixed abilities (e.g. high, medium and low achievers) with the same point of interest about the phenomenon. Students brainstorm to identify the share-interest issue or problem occurred in the targeted phenomenon. The interest issue for each group should be aligned with STS approach, that is, it can be linked science, society and technology with each other (e.g. a social problem caused by science or technology). In this stage, the teacher facilitates students in each group to identify the interest issue or problem that links with the content scope and allocate time and conditions.

3.3. Step 3: Explore Answer of the Targeted Problem

Students work in groups to plan an investigation or study to search for more knowledge and possible answers to the identified issue or problem. The teacher may facilitate students in this stage by suggesting related resources, activities, media, or technology to help students find their solutions.

3.4. Step 4: Construct New Knowledge

Students employ quantitative and/or qualitative methods to analyze data obtained from the exploration phase. The teacher may suggest the quantitative and/or qualitative data analysis process or method in order to ensure that students will gain valid and reliable findings.

3.5. Step 5: Reflect Learning

Students review as well as reflect on knowledge and experiences they gained from the exploration and construction phases. The teacher should encourage students to connect their new knowledge with prior knowledge that they already have. This step may help students further develop their metacognition as well.

3.6. Step 6: Exchange and Share Learning

Each group exchanges knowledge and experience with classmates by sharing knowledge and experiences gained from the STS-PhBL activity with classmates by using interesting and appropriate technology to help deliver the message in an easy-to-understand format to the audience, e.g., PowerPoint, an infographic, a mind map, a poster, and so on. After each presentation, the teacher provides an opportunity for all students to ask questions, discuss, reflect, and/or suggest a more effective process for reaching more completed knowledge.

3.7. Step 7: Apply Knowledge

The teacher encourages students to expand their learned knowledge and experiences by applying them to situations similar to those they already faced in the lesson. Lastly, the teacher assigns a post-test to all students to verify their understanding of the lesson's correct concepts and learning objectives.

After learning the seven teaching steps of the STS-PhBL model, the researchers applied those steps to developing lesson plans aligned with the model. The researchers developed six lesson plans using the STS-PhBL model for teaching the Geohazard topic to grade 12 students. Table 2 illustrates the topic of the lesson plans and their allotted time.

Table 2. The lesson plans using the STS-PhBL model for teaching Geohazard topic.

Lesson plan	Title	Time (Hour)
1	Volcano 1	2
2	Volcano 2	2
3	Earthquake 1	2
4	Earthquake 2	2
5	Tsunami 1	2
6	Tsunami 2	2

The STS-PhBL model and its associated lesson plans were sent to five experts in the science education field. The Index of Item-Objective-Congruence (IOC) of STS-PhBL lesson plans on Geohazard was calculated. The quality of the STS-PhBL model lesson plans was accepted with an IOC higher than 0.80.

After that, the researchers used the paired-samples t-test to analyze students' scores prior to and after learning the STS-PhBL lessons in the Geohazard topic.

Table 3. Grade 12 students' development of problem-solving skills after learning with the STS-PhBL lessons in the Geohazard topic.

Problem-solving skills	n	Mean	S.D.	df	t	Sig.
Pre-test	39	11.74	1.52	38	30.67	0.000
Post-test	39	16.72	1.47			

Table 3 shows that after learning the STS-PhBL lessons, the students significantly improved their problem-solving skills at the 0.05 statistically significant level.

The STS-PhBL model and its seven teaching steps could be considered an alternative pedagogical approach for teaching Geohazard topics to grade 12 students and an effective pedagogical approach for promoting grade 12 students' problem-solving skills. The integration of STS and PhBL into the STS-PhBL model showcases the strengths of both approaches. The STS-PhBL model utilizes intriguing and recognizable phenomena in the surrounding environment to motivate students to independently construct their own knowledge and understand the interplay between science, technology, and society within the targeted phenomenon. The STS-PhBL model also encourages students to take a more active role in the learning process by asking their science-related social or technological questions about the phenomenon of interest.

The two loops of R&D help confirm the quality of the STS-PhBL model. In R1D1, the expert validation shows that the STS-PhBL model and its lesson plans were qualified. In addition, R2D2 confirms that the STS-PhBL model is effective in helping students improve their problem-solving skills. This finding is aligned with Mahavijit (2019) who found that integrating PhBL with active learning into a seven-lesson plan could effectively help students accomplish their targeted learning goals. The STS-PhBL model, which originates from the same root as PhBL, aligns with the findings of this study.

In addition, the STS-PhBL model is effective in promoting grade 12 students' problem-solving skills in the Geohazard topic at the 0.05 statistically significant level. This finding stems from the students' genuine interest and inspiration in resolving issues relating to the targeted phenomenon. Teachers facilitate students' learning by providing possible and related resources, tools, and technologies, putting them on the right track for successful STS-

PhBL learning. When the students in this study encounter real-world problems or issues related to everyday phenomena, they demonstrate a high level of interest and inspiration in these phenomena. This trait can help students learn science effectively and, in particular, develop problem-solving skills. The findings from this study aligned with those from several studies, i.e., Buphee (2016), Ngamchom (2016) and Boonyamanee (2018). These studies showed that STS could remarkably help the students develop their problem-solving skills at the 0.05 statistical significance level.

4. Conclusions

This study's results propose the STS-PhBL model as an effective pedagogical approach for teaching science to grade 12 students and enhancing their problem-solving skills. The R&D process in developing the STS-PhBL model can help science teachers like the first author develop their science teaching profession. The researchers synthesized a new STS-PhBL model and came up with seven teaching steps: The seven teaching steps include: a) stimulating the phenomenon; b) identifying problems within the phenomenon; c) exploring the answer to the targeted problem; d) constructing new knowledge; e) reflecting on learning; f) exchanging and sharing learning; and g) applying knowledge. These STS-PhBL model teaching steps are effective in promoting students to a) meet the goal of science education, b) be able to apply knowledge and solve problems in daily life, c) develop skills in the 21st century, and 4) be the major driving force for the country's human capital development. In sum, the STS-PhBL should be promoted as one of the approaches in the learning management of science with educational reforms that are important to the development of professional teachers and useful in developing problem-solving skills in science for the students.

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