Thai pre-service science teachers' struggles in using Socio-scientific Issues (SSIs) during practicum

Sasithep PITIPORNTAPIN
Division of Science Education, Department of Education, Faculty of Education, Kasetsart University Bangkok, THAILAND
E-mail: fedustp@ku.ac.th

Naruemon YUTAKOM
Division of Science Education, Department of Education, Faculty of Education, Kasetsart University Bangkok, THAILAND
E-mail: fedunay@ku.ac.th

Troy D. SADLER
ReSTEM Institute: Reimagining & Researching STEM Education, The University of Missouri, Columbia, USA
E-mail: sadlert@missouri.edu

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Abstract

In educational reform, teaching through socio-scientific issues (SSIs) is considered the best way to promote scientific literacy for citizenship as the goal of science teaching. To bring SSIs into the science classroom, Thai pre-service science teachers (PSTs) are expected to understand the concept of SSI-based teaching and to use it effectively in their teaching. The purpose of this study is to explore PSTs' use of SSIs in their teaching during practicum, their problems with SSI-based teaching, and their professional development needs related to SSI-based teaching. The research participants were 52 PSTs in the fifth year of their bachelor's program at a Bangkok university during the 2015 academic year. The researchers collected data mainly from questionnaires, supported by classroom observations, PSTs' lesson plans, focus group interviews, and semi-structured interviews with the university supervisors and cooperating teachers. Content analysis was used for data analysis. The findings showed that most PSTs provided inquiry activity unrelated to SSIs for their students' learning. Few reported using SSIs in their teaching practices. Of those who used SSIs in their classroom, most used SSIs about health and behavior to link scientific concepts. They used video clips as the main form of media for informing students about SSIs. However, they brought in SSIs only to launch their lessons, not to drive whole lessons, and their students' role was limited mainly to discussion. They struggled with a lack of confidence in bringing SSIs into their teaching, difficulties in linking SSIs to scientific concepts, and difficulties in eliciting students' prior knowledge of SSIs. In spite of these struggles, they wanted to participate in professional development on using SSI-based teaching. These findings are significant for rethinking teacher preparation in Thailand.

Keywords: Pre-service science teachers, Socio-scientific issues, Science teaching

Introduction

Currently, Thailand is experiencing rapid scientific and technological change. These changes, which have been occurring over that last twenty years, are a response to accelerating economic development that in turn promotes and supports socio-scientific issues (SSIs) such as global warming (Gayford, 2002), polluted water (Bouillion & Gomez, 2001), increasing garbage (Kortland, 1996), and the degradation of natural resources (ONEP, 2004), as well as belief in superstitions and pseudoscience (Lekpet & Pitiporntapin, 2015). SSIs have no clearly defined single outcome or answer and are topics about which reasonable people might be expected to disagree (Lewis, 2003).

SSIs have become important topics for science education and form a link between relevant social issues and science (Kolsto, 2001). To bring SSIs into the science classroom, SSI-based teaching is considered an alternative way for teachers to enhance student learning of specific science content (Sadler, Barab, & Scott, 2007) and to enhance ethical and moral decision-making skills regarding science, technology, society, and environmental issues (Sadler, 2009).

Students learning through this approach have a chance to engage in higher-order practices related to real life situations (Presley et al., 2013), such as analyzing and interpreting data; using evidence to participate in argumentation; and collecting, evaluating and communicating information, which is a kind of scientific literacy (NRC, 2012). In contrast, traditional approaches tend to produce students with epistemological beliefs and justifications, as students are taught in an autocratic fashion (Aikenhead, 2006). A lack of understanding of the interaction between the needs of society and science may lead to feelings of fear, anger, and distrust towards the scientific community (Hodson, 2008).

Nevertheless, bringing SSIs to the classroom is quite new in Thailand. Few studies address SSIs in science classrooms in Thailand, and most focus on the results of SSI-based teaching on students rather than focusing on pre-service science teachers (PSTs)' use of SSIs in science classrooms (Nuangchalerm & Kwuanthong, 2010; Seomsuk, Pitiporntapin, & Kovitvadhi, 2015; Thanapud, Pitiporntapin, & Jantrarotai, 2015). For PSTs' SSI-based teaching, Nuangchalerm (2009) found that many PSTs raised concerns about effectively controlling discussions, teacher–student differences in belief systems, and the distinction between science and ethics in classroom discourse. These problems are similar to those in other countries; Forbes & Davis (2008) found that PSTs in the United States had limited content knowledge about the SSIs. To address this problem, a teacher preparation program could help develop PSTs understanding of this new classroom practice (Bell, 1998).

The teacher preparation program forming the context of this study focuses on SSI-based teaching. It has challenged the researchers to reveal PSTs' use of SSIs in their science classrooms during practicum, to identify any problems, and to determine professional development needs for SSI-based teaching. The findings will help science educators to develop science curricula and teaching that involves the use of SSIs for student learning.

Research Questions

In the context of the current study, the following questions were used to guide the research:

1. Did PSTs use SSIs in science teaching during practicum? If so, how did they do it?
2. What were PSTs' difficulties with SSI-based teaching?
3. What are PSTs' needs for professional development in SSI-based teaching?

Theoretical Framework

To describe and understand science teachers' use of SSIs in the classroom, a few researchers suggest SSI-based teaching frameworks (Presley et al., 2013; Zeidler et al., 2005). These SSI-based teaching frameworks indicate the focus of instruction, the characteristics of instruction (pedagogical choices), the role of teachers and students, and the classroom environment, as shown in detail below.

Teaching Focus

Because of SSIs' characteristics, they incorporate both scientific and social knowledge, as well as social concerns (Ratcliffe & Grace, 2003). Successful teachers use SSIs to teach learning-specific science content (Sadler, Barab, & Scott, 2007) and to connect content to other areas of science or other disciplines. Moreover, teachers provide students the opportunity to learn about the nature of science (NOS) themes in the classroom and to perform higher order practices (Presley et al., 2013) such as analyzing and interpreting data; using evidence to participate in argumentation; and collecting, evaluating, and communicating information, which is a kind of scientific literacy and the focus of the Next Generation Science Standards (NRC, 2012).

Characteristics of Instruction

To be successful using SSIs in the classroom, teachers must provide scaffolding for students to engage in practices such as argumentation, reasoning, and decision-making (Presley et al., 2013). As aids and materials for SSI-based teaching, teachers can use media such as articles from newspapers or magazines, reports, or television interviews to make connections between what students are learning in class and current world events (Klosterman, Sadler, & Brown, 2012). In addition, technology can be used in a variety of ways to enhance SSI-based teaching and is a potentially powerful tool for accessing relevant social issues (Evagorou, 2011). Students can access SSI media resources with technology (Presley et al., 2013). A framework of learning assessment should include students' higher order practices, such as scientific claims and arguments (Kolstø, 2006). To measure student engagement in SSI learning experiences, teachers should use formative assessment in the form of constant feedback to promote learning (Tal & Kedmi, 2006) and provide opportunities for students to reflect on and refine their own ideas (Sadler, 2011). In addition, at the end of a unit or topic, teachers can use summative assessment to capture what students have learned and the quality of the learning or to judge their performance against relevant standards (NRC, 2001).

Roles of Students

The role of students in SSI-based teaching differs from traditional approaches. Students collect and/or analyze scientific data related to the issue being considered, and negotiation of social (e.g., political and economic) dimensions of the issue is expected (Presley et al., 2013). Argumentation is a central point of SSI-based learning classrooms (Zeidler & Nichols, 2009). Students prioritize methods of inquiry while interpreting issues, making decisions, making moral judgments, solving problems, and engaging in various forms of discourse including argumentation, negotiation, and challenging the assumptions of dominant knowledge claims (Serpell, 2011). When students conduct research and make arguments about SSI, they learn scientific content (Klosterman & Sadler, 2010). In addition, moral perspectives are one of the more important components of SSI-based learning (Zeidler & Keefer, 2003). Presley et al. (2013) suggested that students should consider the ethical dimensions associated with an issue. Furthermore, students can evaluate the benefits and risks associated with an issue and may require some understanding of them and their probabilities (Ratcliffe & Grace, 2003). Expressing the risks and benefits of any SSI is crucial for identifying and understanding it (Crick, 2001).

Learning Environment

In SSI-based teaching, teachers should not be authoritarian, such as by presenting the issue at the beginning of instruction, and should relate what students learn to their prior knowledge

(Presley et al., 2013). Sometimes teachers are also learners and contribute their ideas and knowledge to the classroom (Dolan, Nichols, & Zeidler, 2009). They provide opportunities for their students to better understand the scientific and social aspects of an issue and to become aware of the social considerations associated with it (Presley et al., 2013). In addition, there should be a collaborative and interactive environment in science classrooms, with students and teachers demonstrating respect for one another (Presley et al., 2013). A few studies have examined how SSI contexts affect students' epistemologies of science. Eastwood et al. (2013) examined whether SSI-based learning environments affected university students' epistemological understanding of scientific inquiry differently from traditional science educational contexts. The results showed that both groups had a generally adequate understanding of scientific inquiry, but they also held a number of misconceptions. Other researchers have found that teachers can use SSIs as a useful context for learning specific science content (Sadler et al., 2007; Nuangchalerm & Kwuanthong, 2010), employing analytical thinking (Nuangchalerm & Kwuanthong, 2010), understanding the nature of science (Nuangchalerm & Kwuanthong, 2010; Sadler et al., 2007), gaining learning satisfaction (Nuangchalerm & Kwuanthong, 2010), addressing citizenship education (Sadler et al., 2007), improving argumentation skills (Erduran et al., 2004), and enhancing decision-making skills (Sadler, 2009).

Methodology

This research has its roots in an interpretive paradigm. The researchers attempted to understand and explain the ways PSTs used SSIs in science classrooms during the 2015 academic year. The participants in this study were 52 PSTs in the fifth year of a B.Ed. (Teaching Science) program who were doing teaching practice in 17 partnership schools. There were 10 males and 42 females. The age range was 21–23 years old. There were 13 studying chemistry teaching, 13 studying physics teaching, and 26 studying biology teaching. They had learned about SSI-based teaching in some program courses, such as seminars and science teaching methodology and communication courses.

During practicum, they were asked to select one grade level from lower elementary level to the secondary level for their teaching practice. In addition, they were required to teach science 6–8 hours per week for 1 year (2 semesters). Cooperating teachers and university supervisors provided front-line advice, support, and critically reflective feedback to PSTs on developing classroom management skills, lesson plans, and teaching practices. Each semester, PSTs were also required to attend four seminars at the university and submitted their entire lesson plan to the university supervisor at the end of their teaching practice.

To answer the research questions, the researchers asked seven university supervisors to observe each PST's teaching practice randomly four times during the first semester of 2015, jot down what they observed in field notes, and collect PSTs' lesson plans. Beforehand, the researchers told them the objectives of classroom observations and made clear what they should observe, such as the focus of the teaching, characteristics of instruction, role of the teachers, role of the students, and the learning environment. The researchers also asked the PSTs to participate in focus group interviews four times during teaching conferences. At the end of their practicum, the researchers asked PSTs to complete an open-ended questionnaire to elicit their use of SSIs in their teaching during the practicum and to identify the problems encountered and their SSI-based professional development needs. There were three sections in the questionnaire: personal information, use of SSIs in classroom, and need for professional development in SSI-based teaching. In the personal data section, there were five open-ended items related to sex, age, major fields, grade point average (GPA), and SSI-based teaching experience. In the section on the use of SSIs in classroom, there were six open-ended questions related to the definition of SSIs, whether the PSTs bring SSIs into their lessons, how they use SSIs in the classroom, what media they use to bring SSIs into their classrooms, the role of students in SSI-based teaching, and the problems with SSI-based teaching. The section on professional development for SSI-based teaching had two open-ended questions on PSTs needs and the characteristics of the professional development program in which they would like to participate.

To confirm their questionnaire answers, two cooperative teachers per school and six university supervisors were asked to conduct semi-structured interviews to identify whether PSTs used SSIs in their teaching practice and to identify the problems PSTs faced when using SSIs in their classrooms.

For data analysis, all data collected from PSTs, cooperative teachers and university supervisors were analyzed both quantitatively and qualitatively to understand PSTs' use of SSIs in their classrooms, their difficulties in using SSIs, and their need for professional development in SSI-based teaching. Quantitative data analysis involved using descriptive statistics to identify which categories were most commonly answered. For qualitative data analysis, the questionnaire answers were analyzed through content analysis. The interviews were first transcribed verbatim. Then, the researchers read all data to seek relationship patterns. After that, the data were open-coded to look for emerging categories. Furthermore, relationships and patterns among all categories were interpreted and themes or general statements were created to represent PSTs' use of SSIs in their classrooms, their difficulties in using SSIs, and their need for professional development in SSI-based teaching.

With regard to confirmability, details about the data collection, coding, and analysis were examined and reviewed by experts in science education, who provided the researchers feedback on the accuracy of the process.

Findings

The findings from the data analysis are presented in three parts: 1) PSTs' current use of SSI-based teaching, 2) PSTs' difficulties in using SSI-based teaching, and 3) PSTs' needs for professional development in SSI-based teaching.

PSTs' Current Use of SSI-Based Teaching

Most PSTs used noncontroversial issues related to science rather than SSIs for student understanding of scientific concepts.

When the researchers asked the PSTs' views in the questionnaire on the meaning of SSIs, 10 PSTs had a correct understanding of SSIs as social, controversial, relevant, real-world problems that are informed by science and often include an ethical component. One respondent said, *"It occurs in society related to science, but there are still no clear, correct answers, and it is related to ethics. It depends on people's view point" (P09).* On the other hand, 32 PSTs answered that SSIs were hot social issues and were related to science. They were not concerned about the controversial aspects of the issue. One PST said, "It (SSI) is related to science by a social situation about which everyone has recently been interested" (P45). This example showed that PST's understanding of SSIs was different from the correct SSI definition. In addition, 10 PSTs did not answer this question. The reason they gave in their informal interviews was that they had no idea.

When they were asked whether they bring SSIs into their classes, some reported that they took SSIs into their classes to link with scientific concepts. These concepts can be divided into seven groups: health and behavior, chromosomes and genetic materials, weather, the environment, natural resources, and energy, as shown in Table I.

Table I. The group of scientific concepts and related issues that PSTs used in their classrooms

Scientific concepts	Examples of related issues	Frequency(Percentage)
1. Health and behavior	Providing medical care for a superstar infected with Dengue fever, using herbal anti-obesity drugs or glutathione, surrogacy, and believing in child angel dolls	5 (26.32)

2. Chromosomes and genetic materials	GMOs, stem cell treatments to cure disease, identifying birth parents, and cloning	4 (21.05)
3. Natural resources	Constructing of a dam in a national park, selling endangered species, and rearing alien species	4 (21.05)
4. Weather	Climate change, global warming, El Nino-southern oscillation, ozone depletion, and acid rain	2 (10.53)
5. Environment	Oil spills in the ocean, noise pollution from airplanes, garbage dust from coal-fired power plants, use of chemical fertilizer in rice fields, and earthquakes	2 (10.53)
6. Chemical agents	Using chemical agents in the wrong way	1 (5.26)
7. Energy	Constructing a nuclear power plant	1 (5.26)

However, some issues in the table above were used PSTs' classrooms for their noncontroversial aspects related to the scientific concepts that PSTs were teaching rather than for controversial SSIs with no clearly defined single outcome or answer and about which reasonable people might be expected to disagree. These ideas were shown again in their lesson plan and teaching practice. For example, a PST who was investigating food and nutrition introduced the issue "fast food is bad for health" by showing her students a video clip about the dangers of fast food and encouraging her students to answer questions about why the food shown in the video clip was dangerous. After that, she asked her students to do an experiment provided in the textbook examining nutrition in food. When her students finished their experiments, she asked them to present the data they had obtained, followed by a discussion. She ended her class by asking students some questions about the concepts of nutrition as part of a summative assessment: "What is nutrition?" "How many types of nutrition are there?" "How can we examine types of nutrition in food?" In her focus group interview, she stated, *"I intended to use the issue about the dangers of fast food issue to attract my students' interest in the scientific concepts about nutrition" (P51).*

In contrast, another PST brought up the *"dietary supplement"* issue in his lesson on food and nutrition. He started by asking students to read an article that included a variety of positive and negative opinions on dietary supplements. Then, he let students make claims and warrants about whether dietary supplements were good for their health. His students also had the chance to do experiments from the textbook or to search for information about food and nutrition from the Internet to support their ideas. Afterward, he asked the students with different ideas to debate the topic *"is it essential to eat dietary supplements?"* based on the data they had collected. At the end of the debate, he also let his students discuss those aspects of law, economy, ethics, and consumer safety that had led them to make their decision. Before his class finished, he used guided questions to allow students to complete their discussion of the concept of food and nutrition. In his focus group interview, he stated, "*I think that the dietary supplement is good for my students to link their knowledge about nutrition to daily life through debate and discussion about this issue" (P13).* Therefore, the issue this PST used in his class was a SSI because it was a controversial, socially relevant, real-world problem informed by science and included an ethical component.

Most PSTs included SSIs only in the introductory part of the discussion.

When in the questionnaire the researchers asked PSTs how they used SSIs in their classrooms, a majority reported that they provided examples or situations with SSIs and discussed them in the introductory part of the lesson. Others used SSIs as a theme for driving the whole lesson. However, a few provided examples or situations of SSIs and discussed them in the elaboration part of the lesson. Only one PST provided examples and informed students about information related to SSIs, as shown in Table II.

Table II. The ways SSIs were brought into PST classrooms

Methods	Frequency(Percentage)
1. Provided examples or situations of SSIs and discussed them in the introductory part	22 (50.00)
2.Used SSIs as a theme for driving the whole lesson	19 (43.18)
3. Provide examples or situations of SSIs and discussed them in the elaboration part	2 (4.55)
4. Only provided examples and gave students information related to SSIs	1 (2.27)

From classroom observation, the researchers found that most PSTs who used SSIs in their classes focused on SSIs only in the introduction portion of their teaching to attract students' interest in the lesson and did not mention them again. As one PST revealed in a focus group interview, "*I launched my lesson by telling the news about gays asking woman to do surrogacy for them to motivate my students' interest in reproduction before letting them search various kinds of reproduction on academic websites on their cell phones" (P26).* These PSTs' uses of SSIs were confirmed by the cooperating teachers' reflections on their teaching practices. One said: *"A PST told his students news related to SSIs in the introductory part. Sometimes, he talks about SSIs in the elaboration part to link scientific concepts to daily life" (C07).* Their university supervisors reported their use of SSIs in the same way: *"My PSTs that I supervised sometimes brought hot issues to their classes to attract student interest. I sometimes found they used SSIs in their teaching especially in the introductory part or elaboration part because they think that SSIs are related to their teaching concept" (U06).*

Video clips were used as the main type of media by PSTs bringing SSIs into the science classroom.

Data from the questionnaires show that PSTs used various media to link SSIs to their lessons. These media can be divided into seven groups: video clips, newspapers, social media, local learning resources, books, pictures, and leaflets, as shown in Table III.

Table III. Media that PSTs used to bring issues into their science classrooms

Media	Frequency(Percentage)
1. Video clips from radio/television	33 (29.46)
2. Newspapers	28 (25.00)
3. Social media/websites	26 (23.21)
4. Local learning resources such as museums, libraries, experts in the community	9 (8.04)
5. Books/journals	8 (7.14)
6. Pictures from various media	6 (5.36)
7. Leaflets	2 (1.79)

As shown in the table above, video clips were the main media used for bring SSIs into a lesson. Focus group interviews revealed the reasons for this. One PST stated, *"I used SSIs in my class by asking my students to read newspapers, but they did not like reading. In addition, they could not discuss the SSIs they read about because they did not have prior knowledge or experience about the SSIs. To deal with these problems, I used video clips to let students learn about the SSI. Consequently, they were more interested and discussed the topic more in a short time" (P09).* These perceptions were also found in PSTs' lesson plans in which video clips were used to present SSIs to their students. An example is found in one lesson plan: "*Introduction part: 1) Students watch a video clip about the protest about the construction of a dam in a national park. 2) The teacher asks questions about student ideas on what they saw in the video clip. 3) Students explain the way to solve this problem" (P37).*

From observing the classrooms, the researchers found that most PSTs used video clips to provide facts about SSIs, followed by discussion. For example, one PST used a video clip about the greenhouse effect in the teaching step of her lesson on the concept of change in world temperatures. After that, she asked her students about facts in the video: What is global warming? Which gas is a greenhouse gas? What are the effects of the greenhouse effect on the world? Their university supervisors agreed about the use of media to deliver knowledge concerning SSI; one stated, "*Most of the time PSTs used a video clip related to issues to* *present scientific concepts to their students."* However, some PSTs used video clips to motivate students' curiosity and used the inquiry process to elicit knowledge related to SSIs. For example, on the topic of biotechnology, one PST used a video clip about a couple of guys who asked a Thai woman to be a surrogate mother for them. She agreed to do that, but when she gave birth she did not want to give them the baby. After the PST let his students watch the video clip, he asked questions not only about the process of surrogacy, but also about the impact of this SSI on society, such as law, ethics, culture, and so on. In addition, he provided the opportunity for his students to search for information from various learning resources provided in his classroom, such as the textbook and websites, to answer his questions and to discuss the topic together, which led to conclusions on the concept and process of surrogacy and its link to real situations. For this teaching practice, his cooperating teacher seemed to be satisfied with his activities and stated: *"His activity is excellent. He started his lesson with a video clip that could attract student interest and enabled the students to find the answers to the questions he asked. I think that it is meaningful learning" (C04).*

Students' role focused on discussion about SSIs to understand scientific concepts.

With regard to the role of students in the use of SSIs in the classroom, most PSTs reported that the students' role mainly related to discussing SSIs to understand the scientific concepts they were studying, as shown in Table IV.

Table IV. Role of students in using SSIs to support science teaching

Role of Students	Frequency(Percentage)
1. Discussion	20 (38.46)
2. Doing hands-on activities for the construction of scientific concepts	13 (25.00)
3. Doing projects	10 (19.23)
4. Searching for information about SSIs	7 (13.46)
5. Actions in the community such as communications about SSIs with others	2 (3.85)

As confirmed in their lesson plans, most PSTs provided SSI examples, situations, and discussion only in some parts of their lesson, as shown in the following example of a lesson plan: *"In the elaboration part, students watched a video clip about abortion and answered a question about whether it is appropriate to do abortions and whether it is legal to have an abortion in Thailand" (P03).* From the observations, discussion seemed to be the easiest way to bring SSIs into their classes. For example, one PST taught about the effect of chemical agents on the environment. She asked her students at the end of her lesson for opinions about the construction of a nuclear power plant in Thailand even though this question was not in her lesson plan. She reflected, "*I asked my students to discuss the construction of a nuclear power plant because it was a hot issue at that time. I think that my students should be aware about it and they have already learned about the effect of chemical agents on the environment, so they have to use this knowledge to discuss this issue" (P41).* On the other hand, in her focus group interview this PST stated, "*The teacher's role in SSI-based teaching is to bring SSIs into the classroom and moderate student discussions by asking questions and guiding student resources to support their ideas" (P41).*

When the researchers asked their cooperating teachers about the method PSTs used for SSIs in their classrooms, they confirmed that discussion was the main method used. One cooperating teacher stated: "*My PST always asked her students to discuss SSIs. When she taught about animal conservation, she asked her students to discuss buying wild animals to be pets" (C02).* The university supervisor also confirmed that they used discussion as the main method: "*They used issues from newspapers such as global warming to plan their lesson and teaching for students to encourage them to ask questions and have discussions from the beginning of the lesson" (U07).*

PSTs' Difficulties in Using SSIs in the Classroom

The majority of PSTs felt a lack of confidence when using SSIs in their teaching.

Regarding constraints on their SSI-based teaching, 49 PSTs stated that they did not feel confident using these issues in their teaching because they did not have much knowledge about and experience with SSI-based teaching. One respondent said in the questionnaire, "*I don't have much knowledge about this teaching approach, so I only brought a hot issue into my class for discussion by chance" (P40).* They mentioned their lack of confidence again in the focus group interview: "*I am not sure whether what I teach about SSIs is correct or not" (P01).* From classroom observations, some PSTs seemed awkward in controlling classroom discussion on SSIs because they were afraid of certain content. One respondent stated, "*I am worried about using SSIs because they are related to many perspectives. I could not answer some students' questions" (P36).*

As confirmation, the university supervisors also commented on the PSTs' confidence: "*PSTs had to know how to control their classroom effectively. Sometimes they were reluctant to discuss some issues, so they may not be confident. I think that the cooperative teacher should empower them to use new teaching strategies in the classroom" (U05).* The cooperative teacher also noticed their lack of confidence: "*PSTs had insufficient experience when they used SSIs in the classroom. They had to read more. I found that they could not solve problems* *in the classroom when students discussed SSIs, so the cooperative teacher had to help them" (C03).*

The characteristics of some content were difficult to link with SSIs.

Thirty-four PSTs said they had difficulty linking scientific content with SSIs. One mentioned in the questionnaire, "*I think that not every scientific concept can be linked to SSIs. For example in physics, one hardly finds SSIs related to physics concepts except issues about the construction of a nuclear power plant" (P52).* For their lesson plans, they tried to connect issues to biological concepts rather than chemical or physical concepts. They reflected after their practice that if the content were related to an issue, they would not hesitate to link it to that issue. Most of the time, they accidentally linked issues to their lesson depending on the situation, as mentioned before. They did not make a plan beforehand: *"In the case of the actor who got infected with Dengue hemorrhagic fever, it was a hot issue at that time. The doctor said that he had to cut off this actor's leg. I taught about the concept of blood circulation, so I asked my students how come the actor had to have his leg cut off and is it related to blood circulation?" (P28).* Their practices were confirmed by the cooperative teacher, who stated: "*PSTs brought hot issues to discuss in the classroom for some concepts. Most of the time I see them link with biology concepts; for example, one of my PSTs brought up an issue about the actor who became pregnant before getting married to link with the concept of human reproduction" (C01).*

The basic knowledge of students about SSIs was inadequate.

Before they brought SSIs into their classes, all of the PSTs were worried about students' basic knowledge about SSIs. One said in the questionnaire: *"Students have to have basic knowledge about the SSI that is being discussed. If they don't have it when they discuss SSIs, they might not understand" (P11).* During PSTs' teaching practices, their students always kept quiet when they were asked questions about SSIs. Most PSTs who used SSIs in their classes seemed to be disappointed. Some of them directly asked their students for the reasons why they did not answer the questions about SSIs. Eventually, they found that most of their students did not have much knowledge or experience discussing SSIs. One PST revealed in a focus group interview: "*At the launch, I found that my students could not answer my question about GMO plants because they had not known about it, so I had to provide basic information about GMOs before letting them share their opinions again. I found that they discussed more after that" (P34).* This problem was confirmed by a university supervisor who said: "*I found that only a few students asked questions or shared ideas about SSIs. It seemed to be the classroom culture that students waited for the teacher to tell them the main concept, so they* *acted like passive learners. Thus, PSTs have to encourage their students to practice searching for information about SSIs and sharing ideas" (U02).*

PSTs' Needs for Professional Development about SSI-Based Teaching

When asking PSTs about their needs for professional development about SSI-based teaching after they graduated, most stated in the questionnaire that they intended to participate in a professional development program for various reasons. In particular, they wanted to know how to use SSIs in teaching, as shown in Table V.

Table V. PSTs' reasons for participating in professional development

Reasons	Frequency(Percentage)
1. To know how to use SSIs correctly for teaching	23 (58.97)
2. To promote students' understanding of scientific concepts	4 (10.26)
3. To promote students' application of knowledge in daily life	4 (10.26)
4. To promote students' awareness of the importance of science	2 (5.13)
5. To promote students' interest in science	2 (5.13)
6. To promote students' argumentation skills	2 (5.13)
7. To promote students' awareness of the impact of science, technology, society, and the environment	1 (2.56)
8. To promote students' thinking skills	1 (2.56)

They also expressed their need for professional development during the focus group interview. One of the PST stated, "*I am sure that I will participate in the professional development program because I want to develop my SSI-based teaching. I would like to see an example of an SSI-based lesson and adapt it to my class" (P08).* The university teachers support their ideas about participating in a professional development program. One stated: "*I think that most PSTs did not have much knowledge about SSI-based teaching. The science teaching program focused on inquiry-based teaching and a constructivist approach. Fortunately, I found they tried to bring a context related to the content they taught to their class, but most contexts they brought were not concerned with SSIs. To promote their SSI-based teaching, I think that PSTs should first participate in a professional development program to gain knowledge about SSI-based teaching" (U06).* When asked about the characteristics of the professional development program they needed, most of PSTs mentioned convenient access to resources on SSI-based teaching, as shown in Table VI.

Table VI. The characteristics of a professional development program to promote PSTs' SSI-based teaching

Reasons	Frequency(Percentage)
1. Convenient access	29 (61.70)
2. Having clear examples of SSI-based teaching	7 (14.89)
3. Direct discussion with experts	6 (12.77)
4. Providing channels to share opinions	5 (10.64)

Their supporting reasons for participating in a professional development program for SSI-based teaching were confirmed during the semi-structured interviews. One PST said, *"I think that the best way to promote my SSI-based teaching is by having some data about SSI-based teaching that are easy to assess. Providing suggestions from and discussion with experts is needed" (P37).* Their ideas were similar to those of their university supervisors. One university supervisor said, *"I think that there should be a learning package that is easy to assess for PSTs to develop their SSI-based teaching. This package should provide examples of learning units, learning media and materials, and CDs of examples of SSI-based teaching, as well as examples of research" (U01).*

Conclusion and Discussion

The findings show that some PSTs used noncontroversial science issues in their classrooms rather than SSIs. SSIs are considered topics with no clearly defined single outcome or answer and about which reasonable people might be expected to disagree (Lewis, 2003). When considering the scientific concepts they tried to link with SSIs, health and behavior were most often mentioned. Supporting this idea, Sadler, Barab, and Scott (2007) noted that teachers could use SSIs as a context for real-life situations to allow students to learn specific science content knowledge. Among those who used SSIs in their lessons, they intentionally brought SSIs into them but focused on them only in the introductory part. Moreover, the student role was mainly limited to discussion. These practices are different from SSI-based teaching, where students have a chance to collect and analyze scientific data, engage in higher-order practices such as argumentation, reasoning, decision-making, or position taking (Presley et al., 2013). In the present study, PSTs tried to use various media to present SSIs in their lessons, and they found that using video related to SSIs seemed to attract their students' interests. Similarly, Klosterman et al. (2012) found that many teachers tried to use mass media to facilitate students' exploration of SSIs, but their use of frameworks aligned with SSI-based teaching was limited.

Regarding their struggles using SSIs in the classroom, the majority of PSTs felt a lack of confidence using SSIs in their teaching. This was also found by Pedretti et al. (2007), who determined that in the early years of teaching many teachers did not feel confident about teaching related to controversial issues and were reluctant to do so. The PSTs in the present study also pointed out that the characteristics of some content were difficult to link to SSIs. Similarly, Forbes and Davis's study (2008) that found PSTs generally have limited SSI knowledge and, as a result, tend to teach units that focus on the content they are familiar with. For learning media, PSTs used video clips as the main type of media for bringing SSIs into science classrooms, but they used them to provide factual information rather than to promote students' inquiry process. In addition, the PSTs in this study mentioned that students' basic knowledge about SSIs was inadequate. Many reports have pointed out the difficulties students have in making connections between science content and SSI discussion (Sadler, 2004). Sadler and Donnelly (2006) have shown that students use very little of the science knowledge learned in class when they discuss an issue in interviews. One reason comes from the fact that SSIs are often related to frontier science for which there is much uncertainty and no consensus within the science community (Aikenhead, 2006).

Regarding the need for professional development in SSI-based teaching, most PSTs wanted to know how to use SSI issues when teaching. The reason for their need derives from their lack of knowledge about this teaching approach. Similarly, Levinson and Turner (2001) stated that some teachers lacked pedagogical knowledge and had little understanding of frameworks for ethical thinking. Therefore, the findings in this study require science educators and institutions for teacher education to prepare Thai PSTs more on how to use SSIs in their science teaching.

Recommendations

The findings show that most PSTs did not have knowledge about SSI-based teaching. Consequently, they hardly ever used SSI-based teaching in their classrooms. Thus, the researchers suggest that the teacher preparation program should provide clear content and activities related to SSI-based teaching in some courses. In addition, the program should provide learning resources that are easy to assess to obtain more knowledge about SSI-based teaching and to obtain direct suggestions from experts about SSI-based teaching. Because the PSTs were in the last year of their teacher preparation program at the time of the study, they should have already developed their understanding and practices of SSI-based teaching in a correct way. They pointed out their preference for a professional development program, including its ease of access. Thus, a future study should focus on the development of a professional development program to enhance PSTs understanding and practice of SSI-based teaching and to examine the effectiveness of that program in terms of its ease of access for PSTs.

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