

Enhancing Pre-Service Science Teachers' Practices According to Socio-scientific Issue (SSI)-Based Teaching through Collaborative Action Research

Sasithev Pitipornatapin¹, Asawin Thanapad¹, Natphathu Seomsuk¹ & Deanna Marie Lankford²

¹ Division of Science Education, Department of Education, Faculty of Education, Kasetsart University, Bangkok, Thailand

² ReSTEM Institute: Reimagining & Researching STEM Education, The University of Missouri, Columbia, USA

Correspondence: Sasithev Pitipornatapin, Division of Science Education, Department of Education, Faculty of Education, Kasetsart University, Bangkok, 10900, Thailand. Tel: 66-02-579-7114, ext. 161. E-mail: fedustp@ku.ac.th

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Abstract

The objective of this research was to enhance two case studies of pre-service science teachers in master's degree program teaching practices according to socio-scientific issue (SSI)-based teaching through collaborative action research. The case study participants had taken a field experience course at one of the universities in Bangkok during the 2014 academic year. The researcher gathered data from classroom observations, students' journal entries, and student artefacts. In addition, the students were asked to write journal entries about their teaching practices. Moreover, informal interviews were used for clarification. These collected data were analysed using within-case and cross-case analyses. The findings showed that both case studies developed 10th grade students' argumentation skills through SSI-based teaching in a natural resource unit with four stages of teaching (the issue stage, the exploration stage, the argument stage, and the decision-making stage) for promoting student argumentation skills. Based on the collaborative action research, both cases changed their teaching practices to include more minds on activities to hook students' interest in SSIs; an increase in student group work in order to get more essential information; the use of role play to promote effective student argumentation; and adequate time to review the data to better support decision making.

Keywords: pre-service science teachers, socio-scientific issue-based teaching, collaborative action research

1. Introduction

As science and technology continue to change rapidly around the world, these changes produce many socio-scientific issues (SSIs) in which social dilemmas are associated with science; hence, SSI has become an important topic in science education for literacy (Kolstø, 2001). A lack of understanding of SSIs may lead to feelings of fear, anger, and distrust towards the scientific community (Hodson, 2008). Therefore, the link between SSI curricula and the learning of science content remains significant in order to enable students to use their understanding of science to contribute to public debate and make informed and balanced decisions about SSI that impact their lives (Sadler, Barab, & Scott, 2007). However, Pedretti, Bencze, Hewitt, Romkey, and Jivraj (2007) found that in their early years of teaching, many teachers feel particularly confident in teaching controversial issues but are nevertheless reluctant to do so.

Pre-service science teachers (PSTs) represent a particularly important group of prospective science teachers to organizations seeking to acquire effective SSI-based teachers. In the context of educational reform, PSTs are expected to develop their understanding of new classroom practices (Bell, 1998). In another study, an attempt was made to facilitate the newly prescribed teaching and learning process. As a lecturer in a teacher-education institution, the researchers found that collaborative action research is considered a professional development strategy that brings teachers, researchers, and university educators together to collaborate, with the common goal of improving and changing teachers' practice (Capobianco & Feldman, 2006).

Conducting collaborative action research and working with other teachers and educators can help these teachers acquire more useful teaching strategies and better teaching skills (Sagor, 1992). Teachers can develop a deeper

understanding of themselves; they also often clarify their beliefs about teaching and learning science as well as how their actions impact their students' learning (Lebak & Tinsley, 2010). However, research reports investigating SSI-based teaching among PSTs in Thailand are very limited (Nuagchalerm, 2009). Most studies on SSI-based teaching have emphasized student learning from SSI-based teaching instead of focusing on the development of PST teaching practices in SSIs-based teaching (Nuangchalerm & Kwuanthong, 2010; Wongsri & Nuangchalerm, 2010). Therefore, it is a challenge for researchers to use collaborative action research as a professional development strategy to enhance PSTs' teaching practices according to SSI-based teaching.

2. Purpose of This Research

The purpose of this study was to examine the change of PSTs' teaching practices in a master's degree program among PSTs who did not have any prior experience with SSI-based teaching. The study examined PST practices according to SSI-based teaching as a result of collaborative action research. To achieve the purpose of the study, the following research question was posed: What changes in PSTs' practice of SSI-based teaching occurred as a result of collaborative action research?

3. Methodology

3.1 Research Design

Under an interpretive paradigm, qualitative research is naturalistic in that the researchers do not attempt to manipulate or control the research setting because, in this view, the research setting is subject to change (Marshall & Rossman, 2006). To ensure understanding of holistic views or processes in particular instances, the selection of a case is vital to the fields of interpretive study; the purpose of the case selection is to offer understanding of the natural phenomena under investigation (Merriam, 1998). Therefore, this study focused on obtaining rich and detailed descriptions of case studies of two volunteer PSTs' changes in their teaching practices according to SSI-based teaching as a result of collaborative action research.

3.2 Research Participants

The participants in this study were two PSTs who had received scholarships from the Thai government to enrol in a two-year Master of Science education degree program at a teacher education institution in Bangkok. They were in their fourth semester of study when they participated in field experiences as student teachers in an actual school and completed classroom action research. These two case studies were purposefully selected based on three criteria: 1) the teachers volunteered to be research participants; 2) they were interested in understanding the challenges and solutions of SSI-based teaching; and 3) they experienced problems in the classroom related to SSI-based teaching. William and Nancy were the pseudonyms assigned to the two case studies selected to examine the influence of classroom action research on the development of SSI-based teaching.

3.3 Context of the Study

At the time of the study, William was 26 years old. His grade point average (GPA) was 3.93 out of 4. He had no prior experience in SSI-based teaching. William's inspiration for using this approach in his action research was due to the passive nature of his students. They rarely shared their ideas or opinions in the classroom. After class, the students always asked questions about what they did not understand. To address this problem, he designed nine class periods of SSI-based teaching for a unit focused on natural resources. William used a questionnaire and an informal interview to collect data on the argumentation skills of his 12 students: 3 males and 9 females. In his argumentation skills questionnaire, William provided an SSI situation about dam construction in a national park.

Nancy was 23 years old with a GPA of 3.86 out of 4. She also had no previous experience with SSI-based teaching. She found that her students were not aware of any SSIs in their community. They were also rarely involved in utilizing skills, such as argumentation, reasoning, and decision-making. Therefore, Nancy designed five SSI-based teaching lesson plans for a unit about life and the environment. There were 15 students in her classroom: 7 males and 8 females. She collected data using an argumentation skills questionnaire and informal interviews. In her argumentation skills questionnaire, she provided an SSI situation about a sanitary landfill.

3.4 Data Collection

During their teaching practicum, William and Nancy met with the researchers to present their progress and receive suggestions about SSI-based teaching. Collaboration in this study involved the PSTs, the cooperating teacher, and one of the researchers as the university supervisor; all these people worked together to improve both case's teaching skills according to SSI-based teaching methods. Collaboration in this study involved five steps: (a) identifying problems from William and Nancy's teaching experiences according to SSI-based teaching; (b)

discussing ways to solve those problems; (c) designing lesson plans to implement student challenges requiring collaboration; (d) implementing the lessons in their classrooms; (d) reflecting on their teaching practices and subsequent student learning; and (e) revising the next lesson plan based on what was learned.

In addition, both teachers had to maintain journal entries where they discussed problems that they found and any questions that they had. The journal entries were sent to the researcher via appropriated social networks. These social media sites provided a venue for discussion with the researcher and also for reflection upon William and Nancy's teaching practices according to SSI-based teaching. The researcher observed the teachers in the classroom, conducted interviews and discussions, and reviewed their documents (e.g., course outlines, lesson plans, and worksheets). Each case study also involved participants with data collection through semi-structured interviews conducted with one of the researchers both at the beginning and again toward the end of their classroom action research. Each data source was required to be combined with different data sources in order to enhance the validity and crosschecking of the findings via triangulation (Patton, 2002). The researchers also used informal interviews of approximately 20-30 minutes in length for the clarification and facilitating analysis, validity checks, and triangulation.

3.5 Data Analysis

For the data analysis of these two case studies, the researchers used an inductive process, which involved a search for correlations, patterns, and themes. A within-case analysis was made prior to the cross-case analysis. The within-case analysis was conducted using the constant comparative method. The data analysis process for the constant comparative method consisted of four steps: comparing incidents applicable to each category; integrating categories and their properties; delimiting the theory; and reducing and refining the categories and their properties (Lincoln & Guba, 1985). After finishing the within-case analysis, a cross-case analysis was used to make comparisons across the two cases. The researcher read and summarized the relevant themes that emerged with respect to each participant. Similarities and differences were identified based on the research questions.

4. Findings

The findings from the data analysis will be presented according to the research questions. Both William and Nancy used SSI-based teaching in their classrooms in order to promote their students' argumentation skills, as their students had rarely used this skill before. With this focus, they designed their SSI-based teaching lesson with four stages of teaching: the issue stage; the exploration stage; the argumentation stage; and the decision-making stage. In each stage, they changed their teaching practices according to collaborative action research as follows.

4.1 Issue Stage: Finding More Minds-on Activities to Hook Students' Interest on SSIs

William began his SSI-based lesson by asking his students to read a news article about a public protest of the construction of a coal-fired plant. He observed that his students did not pay attention while they read; most of them could not share any ideas they recalled about these problems and any causes of the problem. There were only two students who offered their ideas: "Burning coal to generate electricity produces many gases that affect humans" (Classroom observation during first period on August 20, 2014).

After discussing ways to solve this problem with his cooperative teacher at the time, William decided to open with a video clip of the protest of the construction of the coal-burning power plant to motivate students' interest. As a result, his students seemed to be more interested in this SSI and automatically raised questions to discuss in classroom: "If the government approves this project, what are the effects of the construction of a coal-fired power plant in our community?" (S11) (Classroom observation during first period on August 20, 2014).

When students finished watching the VDO clip, William asked his students about whether or not a coal-burning power plant should be constructed in this community. This question was intended to provide practice for fired students in making a claim, identifying evidence, and constructing warrants about the SSI of power plant construction. He also asked the students to consider the impact of the power plant on natural resources. Based on his students' responses, William reflected in his journal entry that the students have developed multiple claims and warrants. However, he did not tell his students whether their answers were accurate. Instead, he asked his students to search for additional evidence to support their claims and warrants for the next class period.

In Nancy's case, she changed her activity from reading a news article about an SSI to involving students in the collaborative work of searching for additional information about the SSI. At the beginning of her lesson, Nancy integrated SSI about lead mining in the section about the nutrient cycle in the ecosystem. This issue is thought to have a negative effect on the health and environmental quality within the community. When Nancy engaged her

students in a discussion about lead mining, the students did not pay attention to the discussion and could not link this SSI to any scientific concept. Nancy found that most of her students had no prior knowledge about this news; one of her students mentioned, "I have never heard about this issue before because I have never watched TV or read a newspaper" (Student worksheet of S04, from September 8, 2014).

Due to time limitations, Nancy engaged her students in a discussion about SSIs and identified lead mining as a serious SSI currently in the news. However, her students still did not pay more attention when she described SSI in the news. Therefore, Nancy set out to find some activities to promote her students' interests in SSI. Based on a discussion with cooperative teachers and a university professor about launching activities, Nancy decided to ask students to work in groups to search for SSIs related to the specific types of natural resources that they would learn about in that unit. Each student team would then be responsible for a class presentation in which they shared the SSIs they found and discussed them together. With this new approach, Nancy concluded that her students were more focused and also had more interactions in the classroom. One of her students mentioned that, "I gained knowledge about SSI, and it was so much fun to do this activity" (Informal interview S08 from September 10, 2014).

4.2 Exploration Stage: Increasing the Facilitation of Students' Group Work in Order to Gain More Essential Information about SSIs

William asked his students to form teams and create a plan for researching evidence from the library and information technology center in school to support their claims and warrants about the construction of a coal-fired power plant. From his reflection about his teaching practice with the university supervisor, William found that most students worked well together while searching for information according to their plan. However, some students listened to music on YouTube instead of following the assignment directions.

To address this problem, William revised the next lesson plan based on the university supervisor's suggestions to increase student collaboration within teams by acting more like a learning facilitator. Surprisingly, he found that his students used Facebook as a learning channel for communicating information about SSIs with their friends within the group. However, during his students' presentations, William observed that some students read from their notes written on a small piece of paper, which produced a boring atmosphere during the student presentations. Based upon a discussion with a cooperative teacher, William stopped the presentations and instead required the student presenters to discuss their understanding of the issue. Groups whose presentation consisted mainly of reading from their notes were allowed to present again to him after class. At this time, each group of students tried to present data according to their understanding while William acted as their facilitator. This change encouraged the students to obtain more evidence to support their claims and warrants about the construction of coal-burning power plant; one student stated that, "I agree with the construction of a coal-burning power plant because this community is located in a traveling area and requires a lot of electricity. Thus, it is good for people in this community who will not be required to generate electricity from an electric generator" (S03) (Classroom observation during second period from August 25, 2014).

Nancy introduced a topic of discussion, "Should Thailand support lead mining?" as a prompt for students to identify a claim and find supporting evidence during argumentation. Her students identified a claim and developed a warrant to connect the claim to supporting evidence. One student identified the claim as follows: "Thailand should be free from mining because mining causes environmental impacts" (Informal interview S03 from September 3, 2014). After that, Nancy asked her students to work in groups of two to three students to search for evidence and create a mind map that supported their claims and warrants. Based on Nancy's observation of her students' learning, she found that some of the students in each group did not understand their tasks. These students did not have enough knowledge to develop and defend an argument. Therefore, Nancy discussed this problem with a cooperative teacher and later revised her lesson to ensure that every student participated and understood their role in locating evidence to support a specific claim and warrant.

In her next lesson about natural resources, Nancy asked each group of students to search for information on creating manuscripts for role playing. Each student took on a specific task within the context of the SSI storyline. One student might represent the people within a city near the mine and research specific concerns related to location, while another student might represent the government and the importance of lead mining to the Thai economy. In order to promote students' understanding of the overall task of what they worked on in groups, she also asked her students to write a conclusion of their role playing storyline and identify the individual tasks they carried out in the group. As a result of this activity, Nancy reflected in her journal entry that her students worked as a team to decide what data they would need and how to search for the information. Based upon her students' opinions, they seemed to gain knowledge and to be happy with role playing; one of them mentioned that "I

gained knowledge about the conservation of natural resources, and I like role playing in class". (Informal interview S12 from September 10, 2014).

4.3 Argumentation Stage: Using Role Playing to Promote the Effectiveness of Student Argumentation

William planned to use a debate as a teaching strategy for promoting students' argumentation skills about the construction of a coal-fueled power plant issue. During the implementation of this lesson, William acted as the moderator and organized a debate between his students. Students on both sides had the opportunity to debate, and everyone had a chance to present his/her ideas. However, after class was over, William reflected that he still had the dominant role in his classroom. To reduce this role, he decided to use role playing in the next class period to promote student argumentation related to the selling of wild animals. He explained to his students the good characteristics of scientific argumentation and asked different students to act as the prime minister, the minister of transport, the minister of the environment, and the people to debate this issue together in his classroom. Before his students started role playing, they were required to prepare their information about their roles and to present their scripts of the presentation to William. At this point, William would check the quality of his students' information. Finally, William reflected in his journal entry that this activity increased his students' interest in engaging in the activity. One of his students identified that "It makes me understand others and makes me understand the one who is concerned with SSI because I have to search for information about them. The teacher should let me do this activity again" (Journal entry of S05 from September 11, 2014).

At this step of teaching, Nancy remarked to her cooperating teacher that her students were separated by gender during the argumentation. Male students more actively participated in the argumentation than the female students. Female students made arguments that relied upon emotion rather than evidence, while the male students were more focused on offering supporting evidence. They wanted to overcome the opposite side, so they did not accept other's opinions; one of her students' mentions that "It is only a movie, which might not be true. Do you have other evidence?" (Classroom observation during fourth period from August 26, 2014). Moreover, some of her students did have a chance to share their ideas while making argumentation, and one of her students mentioned that "Some of my friends did not have a chance to make an argument because my friends, who presented before me, presented everything I planned to say, so I did not have to present it again" (Informal interview of S04, from September 8, 2014).

Based upon the suggestion of a cooperative teacher, Nancy would like to find a teaching activity that would allow all her students to be involved in scientific reasoning through argumentation. In her next lesson, Nancy used role playing to help her students develop clear viewpoints about the SSI. In one of her journal entry reflections on her teaching practice, Nancy pointed out that her students had the chance to create a storyline for everyone in the group to share their ideas and use scientific evidence to support their claims. As a result of this activity, her students were happy to learn with the activity. They opened their minds and learned new knowledge from their friends, as one of them identified: "I knew about the problem and how to solve the environmental problems of the role playing" (Informal interview of S06, from September 10, 2014).

4.4 Decision-Making Stage: Providing Enough Time for Students to Review Data and Make Decisions

In designing his lesson plans with the cooperative teacher and the university supervisor, William aimed to give his students practice in comparing the advantages and disadvantages of the construction of a coal-fired power plant and make an evidence-based decision about this issue. His students were instructed to write their decisions and support their reasoning with evidence about this SSI by writing a letter to the prime minister. However, William reflected in his journal that this activity took too much time. Most of his students did not finish writing their letters on time. Therefore, William discussed ways to solve this problem with his cooperative teacher and the university supervisor. He finally revised his activity to allow students to complete the assignment outside the classroom and present their letter in the next class period. After watching the students' presentations, William reflected that even the students who were usually quiet and reserved seemed to be happy to share their ideas. William also learned that when students found supporting evidence and shared their information, especially empirical evidence, the students were able to make decisions about the SSI. One student noted: "I like this activity because my writing skills are better than my speaking skills. This activity also allowed enough time for me to think and find information for my letter" (Student's journal entry of S01, from September 8, 2014).

Nancy reflected on her lesson in this step with the cooperative teacher and the university teacher. She concluded that all of her students wanted to win against the opposite team, so they were still using emotion to make decisions. Based on discussions with cooperative teachers and as a university supervisor, Nancy adjusted her activity to address this problem by explicitly explaining to her students the importance of scientific argumentation and the characteristics of strong and weak argumentation: "I will explicitly show my students examples of strong and weak

argumentation. If I find that the students are using emotional reasoning, I will explain to them that scientific argumentation is not done to win but instead to provide reasonable and believable evidence to support a claim. If my students show emotion while making argumentation, they will review the reason behind this SSI. They should not be biased” (Informal interview Nancy, August 26, 2014).

In her next lesson, Nancy did not forget to remind her students that they should not be biased and that they must use evidence to support their claims. Finally, Nancy wrote in her journal entry that her students did not use emotion when they made argumentation. However, Nancy learned that her students needed more time to make their decisions. They wanted enough time to consider the evidence to use to support their decision: “If the teacher gave me more time, I would be more confident of the decision I make” (Informal interview of S04, from September 10, 2014). Nancy realized the importance of additional time and time management when using SSI-based teaching in her teaching practice: “If I have the chance to teach according to SSI-based teaching, I will provide my students with more time to think, and I will manage my teaching time effectively” (Informal interview Nancy, August 30, 2014).

5. Discussion

William and Nancy focused on promoting their students’ argumentation skills using SSI-based teaching. Topcu and Genel (2014) suggested that argumentation, a higher-order practice, is another important characteristic of SSI-based learning environments. In the beginning, both William and Nancy found many problems in their SSI-based teaching, such as the students’ lack presentation skills, the students’ use of emotional reasoning while making argumentation, and a deficiency of collaboration and negotiation skills. This finding was similar to that of Nuangchalem (2009), who reported that most PSTs identified difficulties in teaching using a control discussion approach.

Both William and Nancy had the chance to reflect on their teaching practices, identify problems, discuss possible ways to solve these problems with the cooperative teacher and the university supervisor, and ultimately revise their lessons. As a result of this collaborative work with the cooperative teacher and the university supervisor, they changed their practices of SSI-based teaching in a positive way. This finding was supported by Sagor (1992), who indicated that collaborative action research can help teachers acquire more useful teaching strategies and better teaching skills.

In this study, William and Nancy incorporated the following: more minds-on activities to hook students’ interest in SSIs; increased group work skills to gain essential information; role playing to promote the effectiveness of students’ argumentation; and adequate time for students to review data and make a decision. These best practices showed that the teachers were able to connect their lessons with real-world issues. Similarly, Barrett and Nieswandt (2010) reported that successful SSI-based teaching depends on the teachers’ awareness of social considerations associated with issues, such as potential political, economic, and ethical challenges.

Consequently, William and Nancy reported that most students developed argumentation skills. For example, William acted more like a learning facilitator, and his students gathered more evidence to support their claims and warrants and also presented what they found to others more effectively. In addition, he tried to reduce his dominant role in the classroom and to explain the characteristics of good argumentation so his students had a greater comprehension of others’ viewpoints and understood the nature of the SSI. Nancy tried to be more of a learning facilitator as well. Her students demonstrated greater participation and understanding of their roles in locating evidence to support a specific claim and warrants. Importantly, when she found her students using emotional reasoning, Nancy explicitly identified the weak point of the argumentation to force students to consider the importance of argumentation and the characteristics of good argumentation. Therefore, these students learned more from classroom discussions that were focused on the practice of argumentation and the characteristics of good argumentation that William and Nancy presented in classroom discussions prior to or during student-led argumentation. Similarly, Osborne (2004) found that providing students with an example of good argumentation can promote students’ argumentation skill development. In addition, these developments could be the result of their awareness of social consideration.

6. Recommendations

The findings showed that collaborative action research affected these two cases’ teaching practices. They tried to improve their SSI-based teaching to solve problems found in their classrooms. Therefore, the researcher suggested that professional development about SSI-based teaching should include engaging teachers and PSTs with collaborative action research. In addition, the researchers also found that the students of the PSTs tended to develop stronger argumentation skills. The researcher suggested that SSI-based teaching could be an effective venue for developing students’ argumentation skills. In future studies, the researcher will investigate the quality

of students' informal reasoning skills about SSI concepts as well as the application of argumentation skills in daily life.

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