EXPLORING PRE-SERVICE TEACHERS' ARGUMENTATION SKILLS, SOCIOSCIENTIFIC ISSUES (SSI) RELATED KNOWLEDGE AND PEDAGOGICAL CONTENT KNOWLEDGE

by

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MENEROKA KEMAHIRAN ARGUMENTASI, PENGETAHUAN BERKAITAN ISU-ISU SOSIOSAINTIFIK (SSI) SERTA PENGETAHUAN PEDAGOGI ISI KANDUNGAN (PPIK) DALAM KALANGAN GURU-GURU PRA PERKHIDMATAN

ABSTRAK

Objektif kajian ini adalah untuk meneroka perubahan dalam kemahiran argumentasi, pengetahuan berkaitan isu-isu sosio saintifik (SSI) dan pengetahuan pedagogi isi kandungan (PPIK) pada guru pra perkhidmatan semasa pendedahan progresif kepada projek berasaskan SSI. Kajian kualitatif ini dijalankan dengan enam belas guru pra perkhidmatan sains dari Institut Pendidikan Guru di Malaysia. Kajian ini dilaksanakan semasa pelajar-pelajar ini berada pada tahun akhir Program Sarjana Muda Perguruan. Sebanyak lima projek-projek berasaskan SSI telah dilaksanakan sebagai satu komponen kursus Sains, Teknologi dan Masyarakat sepanjang tempoh satu semester. Pelaksanaan projek berasaskan SSI sangat relevan dengan konteks yang dikaji kerana pelajar ini akan menyertai kerjaya perguruan setelah tamat kursus ini. Terdapat bukti kukuh bahawa guru-guru pra perkhidmatan mempunyai potensi untuk mengakses bilangan pelajar yang ramai dalam pelbagai gred dan tahap yang berbeza sepanjang kerjaya mereka. Oleh itu, mendidik kumpulan pelajar ini mengenai SSI adalah penting. Kemahiran argumentasi dan pengetahuan berkaitan SSI diukur menggunakan ujian soalan terbuka, temu bual dan pemerhatian. PCK diterokai dengan menggunakan ujian soalan terbuka dan temubual. Kemahiran argumentasi telah dianalisis dengan menggunakan Corak Argumentasi Toulmin (TAP) dan lima tahap kemahiran argumentasi oleh Erduran. Analisis tematik telah dijalankan untuk meneroka pengetahuan berkaitan SSI serta PCK mengenai projek berasaskan SSI. Triangulasi yang diperoleh daripada ketiga-tiga langkah itu menunjukkan bahawa guru pelatih memperolehi kemahiran argumentasi dan pengetahuan berkaitan SSI yang lebih baik secara progresif selepas mengalami lima projek berasaskan SSI. Pengetahuan berkaitan SSI yang diperolehi oleh guru pelatih juga adalah selaras dengan pengetahuan kandungan kurikulum STS. Kajian ini juga menunjukkan pemerolehan pengetahuan PPIK yang lebih baik mengenai projek-projek berasaskan SSI dalam tiga bidang iaitu kurikulum, pengajaran dan pentaksiran. Memandangkan kemahiran dan pengetahuan ini sangat penting dalam abad ke-21, mendidik bakal guru mengenai aspek-aspek ini tidak dapat dielakkan. Penemuan kajian ini mencadangkan bahawa projek berasaskan SSI adalah salah satu cara yang berdaya maju untuk melakukan ini. Implikasi kajian yang berkaitan dengan pendidikan guru pelatih, sumbangan dan cadangan untuk penyelidikan selanjutnya telah dihuraikan.

EXPLORING PRE-SERVICE TEACHERS' ARGUMENTATION SKILLS, SOCIOSCIENTIFIC ISSUES (SSI) RELATED KNOWLEDGE AND PEDAGOGICAL CONTENT KNOWLEDGE

ABSTRACT

The objectives of this study were to explore the changes in pre-service teachers' argumentation skills, socio scientific issue (SSI)-related knowledge and pedagogical content knowledge (PCK) upon progressive exposure to SSI-based projects. This qualitative study was carried out with sixteen pre-service science teachers from a Teacher Training Institute in Malaysia. At the time of study, these students were in the final year of the Bachelor of Teaching Degree Programme. SSI-based projects were implemented as a component of Science Technology and Society course in five topics over a period of one semester. Implementation of SSI-based projects is highly relevant with the context studied as these students will be joining the primary teaching profession after completing this course. As there is strong evidence that pre-service teachers have the power to access multiple number of students across different grades and levels throughout their career, educating these groups of students on SSIs is imperative. Argumentation skills and the knowledge were explored using open-ended tests, interviews and observations. PCK was explored using open-ended tests and interviews. Argumentation skills was analysed using Toulmin's Argumentation Pattern and Erduran's five levels of argumentation skills. Thematic analysis was carried out to analyse acquired SSI related knowledge and PCK about SSI-based projects. Triangulation of the findings obtained from all the three measures indicate that the pre-service teachers acquired improved argumentation skills and SSI related knowledge progressively after experiencing a series of five projects on SSI. The acquired SSI related knowledge was also in line with the required content knowledge of the STS curriculum. The study also indicates improved knowledge of PCK about SSI-based projects in three domains which are curriculum, instruction and assessment. As these skills and knowledge are remarkably important in the 21st century, educating the pre-service teachers on these aspects is inevitable. The findings of this study propose that SSI-based projects are one of the viable means to do this. The implication of the study with respect to teacher education with some highlights on the limitations of the study as well as contributions and suggestions for further research have been provided.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

The Malaysian Education Blueprint (2013 – 2025) aims to transform the national education by increasing the access to quality education and by improving efficiency in the delivery of education. In the pursuit of materialising the vision and mission of 2020, benchmarking the learning of Mathematics and Science to international standard, access to quality education, human capital development and the educational competitiveness of Malaysian schools have been ranked as some of the most important challenges in reaching the status of fully developed country by the year 2020 (Mohamad, 1995).

Various factors influence the country's ability to address the aforementioned challenges. Providing quality education includes benchmarking learning of science and mathematics to internationals standards, revamping assessments to increase focus on higher-order thinking skills, strengthening Science, Technology, Engineering and Mathematics (STEM) education and revamping the Institute of Teacher Education Malaysia (IPGM) to world-class standards (MOE, 2012). In terms of curriculum, high quality is reflected when the contents are timely and directly relevant to the students' daily life (Robottom, 2012). High-quality education also requires the teachers to be trained with the ability to impart the knowledge which is timely and relevant in solving learners' everyday issues (Zeidler & Keefer, 2003).

Specifically, in the context of science education, it is imperative to educate the students with knowledge that are applicable in their daily life. Namely, with the advancement of technology which resulted in the increasingly globalized nature of 21st century, it is redundant to still teach the students with the outdated knowledge available in the textbooks (Bencze, Sperling, & Carter, 2012). Furthermore, adverse destructive phenomena mainly related with environmental issues which ultimately affect the citizens' daily routine, need to be an integral part of the curriculum in order for the content to be relevant (Sadler, 2009a).

Much attention has been given by educators in the use of socioscientific issues (SSIs) as instructional contexts for learning science (Erduran, Simon, & Osborne, 2004; Pinzino, 2012; Sadler, Barab, & Scott, 2007; Sadler, Romine, & Topcu, 2016; Shea, 2013). SSIs involve the deliberate use of scientific topics that require students to engage in dialogue, discussion and debate (Kara, 2012). SSIs are usually controversial in nature and they require reasoning and the evaluation of ethical values in the process of arriving at decisions regarding possible resolution of issue-based problems.

The ultimate purpose of opting to use SSIs in the classroom is to ensure that the lessons are personally meaningful and engaging to students. This is because investigating SSIs require the use of evidence-based reasoning. As such SSIs are frequently used as a platform for understanding scientific information (Zeidler & Nichols, 2009). Research revealed that using SSIs as an instruction to teach science improved learners' content knowledge (Sadler et al., 2016). This is because SSIs presented in the classroom were contextual, localized, and relevant to the community of the learners. The characteristics of SSIs encouraged learns to engage in exploring the issue. Thus, meaningful learning was executed with SSIs (Kyburz-Graber, Hofer, & Wolfensberger, 2006).

Argumentation is one of the 21st-century skills, is the skill required for the students to secure a better living in the future and to make informed decisions about their life and living (Osborne, 2007). As learning about SSIs deals with ethical and moral considerations of scientifically defined and socially relevant issues, SSIs would be an appropriate approach to cultivate argumentations among students as SSIs, when used in the classroom, required the students to explore the issues and provide reasoning with evidence and ethical consideration of the issues.

Literature also indicates that in some instances, SSIs are presented as an instructional pedagogy or teaching approach (Driver, Newton, & Osborne, 2000a; Sadler, 2009b; Zeidler & Keefer, 2003). In training the teachers, introducing SSIs as kind of teaching approach possibly is way to introduce 21st-century pedagogical content knowledge to the trainee teachers. Particularly, the project-based platform is recognized as one of the appropriate means of introducing SSIs in the curriculum and SSI-based projects is therefore, appropriate to be exposed to the pre-service teachers as an instructional strategy (Robottom, 2012).

1.1 Background of the Study

The Institute of Teacher Education Malaysia (IPGM) is the major academic institution that trains students to become teachers at the primary level of education. The training of primary school teachers is carried out at the Institutes of teacher training (IPG) which offer the Bachelor of teaching programme (PISMP). This programme was first launched in 2007 and it is carried out in 27 teacher training institutes. This programme aims to produce quality primary school teachers in terms of knowledge, skills and professional competencies in line with the National Philosophy of Education.

The teacher education curriculum focuses on the holistic development of pre-service teachers (PSTs), and aims to build PSTs' character so that they can face future challenges and to encourage lifelong learning. As a prerequisite to enroll into Bachelor of Teaching program, students first have to complete a one-year preparatory program (PPISMP). Enrolling in teacher training courses is only possible when students have completed their Malaysian Certificate of Education (SPM) with at least five distinctions.

The science teacher education mainly focuses on educating the PSTs on content knowledge, process skills, and pedagogical approaches to teach science, assessment and evaluation and lab management. The focus of the science teacher education program is executed in 13 different courses that the PSTs need to enroll during the duration of the four years program. These courses are Life and living processes; Children's learning in science, Exploring materials, Primary science curriculum and pedagogies, Physics in context, Thinking and working scientifically, Ecosystem and biodiversity, Planning to teach primary science, Energetics in chemistry, Earth and space, Evaluation in science teaching, Management of the science laboratory and resources, Science technology and society and Action research (IPGM, 2015). The Science technology and society (STS) is taught during the final semester of PISMP. The STS course, comprising of five topics, discusses issues relating to science, technology and society and the course is taught using project-based learning as the teaching strategy. This course aims to expose PSTs to topics on Design, innovation and inventions, Conservation, Energy in the biosphere, Additives in food and Endurance of resources (IPGM, 2015). Through this course, the PSTs are expected to acquire the knowledge on topics taught during the course.

Socioscientific issues (SSIs) are controversial social issues that have scientific elements and these issues require reasoning so that learners can find the possible resolution of issues (Sadler et al., 2007). Examples of SSIs include genetically modified plants, pollution and climate change. This approach strives to educate and identify reasoning that supports informed decisions while constructing scientific knowledge (Cinici, 2016; Sadler, 2004b; Zeidler & Nichols, 2009; Zeidler, Sadler, Simmons, & Howes, 2005a). As the issues are contextual, localised, and relevant to the community (Kyburz-Graber et al., 2006) using the issues in the classroom encourage exploration of the issue. Literature also indicates that SSIs is an effective teaching pedagogy (Driver et al., 2000a; Sadler, 2009b; Zeidler & Keefer, 2003) that teaches students on 21st-century skills such as adaptability, complex communication skills, and the ability to solve non-routine problems (Chang & Chiu, 2008).

Implementing SSIs in the STS course is very much appropriate with the content of STS course which requires learning of scientific issues that are relevant to the society. Using SSIs to deliver the content of STS course is appropriate as in the past it was dictated that SSIs provided a deeper understanding of content knowledge when integrated into STS course (Chowdhury, 2016). Particularly, the appropriateness of project-based approach to introduce SSIs where deliberately indicated in the past (Blumenfeld, Marx, Krajcik, Guzdial, & Palincar, 1991; Mergendoller & Thomas, 2001). Project-based learning (PBL) involves students in meaningful tasks such as decision-making and problem-solving. PBL also allows learners to work independently to construct their own learning while engaging in producing realistic, student-generated products (Bell, 2010). The teaching of STS course at IPG requires PBL as the teaching strategy. Hence, it is most appropriate that SSI is incorporated in the STS course as project base as it fulfills the requirements of the course structure.

Introducing SSIs using the project-based platform is in line with the claim that SSIs is best presented as a PBL pedagogy as it enables students to work over extended periods of time; and produce realistic products or presentations (Blumenfeld et al., 1991; Mergendoller & Thomas, 2001). In following this claim and also as a requirement of the STS course, SSI-based projects (SSIBPs) were introduced in this course. SSIBPs were presented using 8-step model adapted from Pacific Education Institute's PBL Model. The steps in this model include investigating, evidence-based reasoning and finding resolutions to issue-based problems.

Different studies indicate that since learning about SSIs deals with ethical consideration of the issue, it is a mean for lifelong learning as SSIs is about exploring the real-life issues (Lee, 2007; Lewis & Leach, 2006; Pinzino, 2012; Tomas & Tonesa, 2011). These same studies indicated that while exploring the real-life SSIs, the learners engaged in proposing arguments and providing evidence-based reasoning in arriving at a decision about the issue. In fact, among the PSTs experiences dealing with SSIs resulted in them in being more aware of the ethical values and understand the connection between science and society (Chowning, Griswold, Kovarik, & Collins, 2012a) and also finding justifications on their standing over the issues (Greaves-Fernandez, 2010). In another study, it was said that the PSTs were emotionally engaged in findings resolution to the issues and this subsequently caused learning using SSIs more meaningful among the PSTs (Soobard & Rannikmae, 2011; Troy & Sadler, 2002). However, Forbes & Davis (2008) reported that PSTs had limited knowledge about SSIs and hence it has been suggested that a teacher preparation program could help develop

PSTs' understanding of this new classroom practice (Bell, 2010; Pitiporntapin, Yutakom, & Sadler, 2016).

Argumentation is a process of proposing, supporting, criticizing, evaluating, and refining ideas, some of which may conflict or compete, about a scientific issue (Kuhn, 2010). In promoting argumentation, conditions that encourage argumentation such as the use of appropriate teaching approaches is recommended (Duschl & Osborne, 2002; Jiménez-Aleixandre, 2007; Rodri, Jime, & Duschl, 2000). In scientific argumentation, learners attempt to support, challenge, or refine a claim on the basis of evidence (Norris, Philips, & Osborne, 2007). As such SSIs would be an effective platform that encourages argumentation (Evagorou & Osborne, 2013; Sadler & Donnelly, 2006; Salvato & Testa, 2012). This is because exploring SSIs deals with ethical consideration of the issue (Lee, 2007); requires finding justification and moral reasoning (Lewis & Leach, 2006). Most importantly, the issue links science and society (Chowning et al., 2012). Argumentation is important for PSTs because their understanding of scientific argumentation impacts how they incorporate this important scientific practice in their future classrooms (McNeill & Knight, 2013). In addition, skilled teachers who understand scientific argumentation and value this type of activity will enable them to promote meaningful learning in science (McNeill, Lizotte, Krajcik, & Marx, 2006; Simon et al., 2006)

Toulmin's Argumentation Pattern (TAP) defines six different structural components that make up an argument: claim, data, warrant, backing, qualifier and rebuttal (Toulmin, 2003). Erduran, Simon, & Osborne, (2004) have further refined the Toulmin's framework and presented the skills in five levels. Erduran et al. (2004) categorised quality of argumentation skills in five different levels where level 1 reflects on lower argumentation skills and level 5 reflects the highest level of argumentation skills. The quality of argumentation depends on the structural components of the responses. Argumentation at level 1 consists on simple claims; level 2 consists of a claim with either data, warrants or backings only; level 3 consists of a series of claims with either data, warrants or backings; level 4 consists of a claim with a clear rebuttal and level 5 consists of an extended argument with more than one rebuttal.

Teaching SSIs helped PSTs to link science content knowledge to real-life situations. Studies revealed that reflective approach of SSI provided deeper understandings and conceptualisation of science content (Lederman, Antink, & Bartos, 2014; Pinzino, 2012). This is because SSIs required an in-depth understanding of science content knowledge in order to engage in argumentation when attempting to solve SSI-related problems (Greaves-Fernandez, 2010). The primary science curriculum includes the teaching of topics that require understanding about stability and products; conservation of water; energy and biosphere; food additive; and pollution (IPGM, 2015). In teaching these topics it is imperative for the teachers to have sufficed and timely knowledge on the issues. Integrating SSIs related to these topics would possibly assist the students to acquire better knowledge of the issues. This is because SSIs deal with the meaningful exploration of real-life issues that connect science and society (Tytler, 2012). In exploring the issues students are required to discuss, argue, justify and make an informed decision (Robertshaw & Campbell, 2013). Some studies also reported that incorporating SSI in teaching enabled PSTs to engage in higher order processes such as investigating, analysing, reasoning and problem-solving. In this way, learning science content becomes more meaningful (Chowning et al., 2012). This subsequently resulted in PSTs having a better understanding of the issue.

Pedagogical content knowledge (PCK) is a type of knowledge that integrates the teachers' pedagogical knowledge and their subject matter knowledge (Shulman, 2010). According to Nuangchalerm (2012), PCK is an understanding of what makes the learning of specific topics easy or difficult because students bring misconceptions to the science class and it is the teachers' role to rectify so that science content is comprehensible to students. Thus, PSTs have to acquire appropriate knowledge of PCK besides science content knowledge in order to disseminate scientific knowledge effectively (Aydeniz & Kirbulut, 2014.; Tosunoglu & Lederman, 2016). Shulman, (2010) asserted that it is imperative for the teachers to acquire the PCK on SSIs and further said that quality SSI instruction requires teachers to be able to effectively teach SSI in their classroom. In their study, Tosunoglu and Leaderman (2016) identified knowledge about the curriculum and pedagogy are the components of PCK on SSI the teachers should know. Knowledge of curriculum comprises of information about SSI that fits into the existing curriculum, type of science concepts could be taught using the SSI, the important SSI that should be included in the curriculum, and what are the learning objectives of the existing curriculum that are related to the SSI. In terms of pedagogy, it's about knowing how to use SSIs instructionally in the classroom, the advantages and how to address misunderstanding using SSI.

In a different study, Aydeniz & Kirbulut (2014) reported that besides the knowledge of curriculum and pedagogy, PCK also encompasses knowledge on assessment. In this study, a PCK assessment tool was designed to enable the pre-service science teachers to engage in reflection so that knowledge of assessment strategies for learning becomes visible to them. In terms of assessment, Aydeniz & Kirbulut (2014) found that PSTs with a high understanding of assessment focused on questions that held potential to engage students in inquiry, reflection, and creativity rather than the acquisition of factual knowledge.

1.2 Statement of Problem

Globally, students' declining interest in science classes is described in several studies (Lyons, 2006; Tosunoglu and Leaderman, 2016). It has been reported that disinterest in learning science among students mainly happened because of the science in the school system usually taught without expressing the relevance to students' everyday living (Presley et al., 2013). Some studies also have indicated that both content of the school science and how it is taught appears rhetoric without any space or platform for discussion. In other words, these studies emphasize that the nature of teaching approach failed to create a platform for effective learning (Oskarsson, Jidesjo, Karlsson, & Stromdahl, 2009). In a different study, it was explicitly mentioned that students seek to learn more contemporary sciences such as health issues, environmental issues and astronomy (Oskarsson et al., 2009).

Osborne & Dillon (2008) in their study further heightened the need for the use of more contemporary teaching approaches in making the lessons relevant. They argued that pedagogical strategies play an imperative role in imparting knowledge needed to live in a modern society. Among the science teachers, teaching approach focuses on rhetorically recalling of science facts appears dominant (Erduran et al., 2004). This happens probably because from the early stage the teachers might have been exposed to this kind of teaching and most probably during the training at teacher education program the teachers were taught by using this kind of approach (Erduran et al., 2004).

Much attention has been given by educators to the use of SSIs as an instructional approach to teaching science (Erduran et al., 2004; Sadler et al., 2007). Studies on SSI so far have focused on students' decision making (Greaves-Fernandez, 2010), conceptual understanding (Zohar & Nemet, 2002), and engagement with science (Albe, 2008) and there are few researches in teacher education that connects science to everyday life (Dawson & Venville, 2010; Kara, 2012). This lacking calls for the integration of SSIs in teacher education curriculum (Evagorou & Puig Mauriz, 2016; Glazewski, Shuster, Brush, & Ellis, 2014). Further using SSIs in the science classroom is appropriate as it is evident that teachers make less attempt to connect science with everyday life because they find it difficult to coordinate scientific data with the social aspects of the problem which bring uncertainty into the discussions (Zeidler, Sadler, Simmons, & Howes, 2005a)

In the Malaysian context, there are some initial efforts of infusing SSIs in secondary and primary level (Foong & Daniel, 2013; Karpudewan, Roth, & Sinniah, 2016), particularly, the teaching STS using SSI based instruction. However, integration of SSIs particularly in the teacher education curriculum is not well documented. Pitiporntapin et al., (2016) reported that PSTs had problems using SSI in their teaching during the practicum. Among the problems identified were: the use of SSI only as set induction and not to drive the whole lesson; using discussions only as the main activity; lack of confidence in handling SSIs; difficulty in linking SSI to science concepts and difficulty in eliciting prerequisite knowledge of students. Efforts have been made to expose PSTs to argumentation with SSI as the platform (Cinici, 2016; Robertshaw & Campbell, 2013b; Rustaman, 2017) but these are few. As PSTs' argumentation level is low, it has been strongly suggested that PSTs need help to better understand the role of argumentation so that they are able to carry out this discourse on their own future classrooms (Simonneaux, 2013). As PSTs are products of the classrooms where argumentation is scarce (Erduran, 2014; Erduran et al., 2004), it is important for pre-service science teachers to be equipped with the knowledge and skills of how to use argumentation to facilitate the learning of their prospective students.

Studies revealed that PSTs have some shortcomings regarding PCK (Al-Amoush, Usak, Erdogan, Markic, & Eilks, 2013; Aydin & Boz, 2012) more specifically PCK on SSI. This mainly happens because the pre-service classroom experiences focus on the acquisition of facts and often ignored process-oriented skills or issues related to the topics (Al-Amoush et al., 2013; Zeidler et al., 2005). Specifically, Bektas, (2015) reported PSTs were lacking knowledge of curriculum, instruction and assessment. The fact that teachers find it difficult to make the connection between science and the social aspects of science (Zeidler et al., 2005) prove that they have little pedagogical knowledge when approaching the teaching of science using SSI. PSTs have to gain PCK in SSI-based instruction because they need to be familiar with the main methods of this approach which emphasise upon the construction of knowledge. (Oliveira, Akerson, & Oldfield, 2012; Windschitl, Thompson, & Braaten, 2007).

SSIs have been infused into teaching science in various ways: the investigative case-based learning approach decision-making model (Gutierez, 2015) and project-based approach (Evagorou, Guven, & Mugaloglu, 2014; Robottom & Simonneaux, 2012). SSIs incorporated in project-based learning is recognized as the best possible method to introduce SSIs (Robottom, 2012). There are many available studies reported on the SSI-based projects that improve content knowledge (Evagorou et al., 2014; Robottom, 2012). However, previous studies particularly, focus on specific SSIs. Studies that focus on the SSIs discussed in this research have not been reported. For instance, there are studies on genetically modified food (Ekborg, 2008) environmental issues (Christenson, Chang Rundgren, & Hoglund, 2012; Kilinc, Demiral, & Kartal, 2017) and nuclear power (Jho & Mijung, 2014). However, studies that describe on a range of SSIs found in this study is not found.

1.3 Purpose of the Study

The purpose of this study is to explore the changes in pre-service science teachers' argumentation skills, SSI-related knowledge and PCK upon progressive exposure to SSIBPs when in the STS course during a period of 10 weeks.

1.4 Objectives of the Study

This study is intended to achieve the following objectives:

i. To explore the changes in argumentation skills among pre-service teachers upon progressive exposure to SSI-based projects.

ii. To explore the change in SSI-related knowledge among pre-service teachers upon progressive exposure to SSI-based projects.

iii. To explore the change in pedagogical content knowledge among pre-service teachers upon progressive exposure to SSI-based projects.

1.5 Research Questions

The following research questions are to be answered in carrying out this study:

i. How does pre-service teachers' argumentation skills change upon progressive exposure to SSI-based projects?

ii. How does pre-service teachers' SSI-related knowledge change upon progressive exposure to SSI-based projects?

iii. How does pre-service teachers' pedagogical content knowledge change upon progressive exposure to SSI-based projects?

1.6 Significance of the study

SSI-based instructions are receiving attention worldwide and researchers have and are carrying out studies to find out its effectiveness in science education. As such the findings of this study are significant for various stakeholders. Most importantly, the introduction of SSIs in teacher education curriculum signifies an effort for curriculum transformation that is in line with the aspirations of the Malaysian Educational Blueprint to raise the standards of teacher education. The study benefits the PSTs as these teachers will be assigned to teach science in schools. The PSTs are expected to apply the knowledge gained from learning the STS course using SSIBPs in their actual teaching. Particularly, the knowledge of PCK would enable the teachers to teach the 21st-century skills using SSIs in a more engaging manner. Additionally, introduction of SSIs in the pre-service teacher education curriculum in some ways, is expected to reflect on the transformation towards the 21st century education.

The findings of this study will interest researchers who are studying SSIs because of its rich and detailed findings from a qualitative research. This study can be used as a reference for future studies on SSIs. Studies on PCK of PSTs about SSI-based instructions are few and this study provides detailed evidence because of the qualitative nature of the study. Researchers who are keen to develop PCK of PSTs in the area of SSI-based projects will find this study useful. In addition, teacher education program need to incorporate pedagogical skills that are relevant to the 21st century.

This study is also important for curriculum designers and planners in planning a science curriculum that incorporates SSIs. It will draw the attention to focus on the importance of incorporating SSIs, particularly in a project-based approach, in the current science curriculum and also the teacher education curriculum. This is because the SSI framework calls for instruction based on inquiry by engaging learners in higher-order processes such as investigating, analysing, evidence-based reasoning, decision making and problem-solving. The project-based approach in this study is most appropriate to carry out these activities by making SSIs the centre of the project, based on which the activities are planned.

1.7 Limitations of the Study

This study is intended to achieve the objectives stated above. Although there are many subjects taught at the IPG, this study only focuses on the subject Science technology and society which is taught at the final semester of the degree programme (PISMP). However, it is important that SSI is intergrated in the PPISM curriculum because firstly, PSTs are exposed to SSI instruction for the first time and hence, they will be aware of SSI instruction as a new pedagogical approach. Secondly, this study will assist and guide teacher educators and researchers to carry out and research SSI instruction in other courses in the teacher education curriculum. More PSTs can be involved in future studies focusing in other courses besides STS in the teacher education programme.

Researchers have taught various topics using SSI. In this study, the SSI were focused on only the five topics in the STS curriculum. This is because the study was carried out on the PSTs during one semester when this course was taught. Researchers have studied SSI with a wide number of topics such as environmental issues, health issues and nuclear energy. Thus, it is important that SSI instruction is carried out in these five topics so that awareness is created amongst PSTs about SSI. They in turn will be able to carry out SSI instruction in their future classrooms.

Various methods have been used to analyse argumentation skills. In this study, Toulmin's Argumentation Pattern (TAP) was used in this study to analyse PSTs' argumentation skills. The quality of PSTs' argumentation skills was analysed according to Erduran's framework. This method of analysis enabled the researcher to obtain a systematic and clear picture of the progress in PSTs' argumentation skills. In addition, TAP has been used for the analysis of arguments in many studies because it has been used extensively to help students and teachers to learn how to construct good scientific arguments (Erduran et al., 2004).

Shulman (1986) originally in reporting in PCK of PSTs has categorized PCK into seven categories. These categories have been further reconceptialised by other researchers according to the focus of their research. For instance, in exploring PSTs' PCK on inquiry based approach, (Edwards, 2013) focused on curriculum and assessment. Similarly, in a study by (Aydeniz & Kirbulut, 2014), curriculum, instruction and assessment focused on three important domains of PCK. As such following Aydeniz and Kirbulut (2014) suggestions these three domains of PCK were investigated in this study. This is because it is important that PSTs understand these three basic domians of PCK.

The qualitative study employed in this study enables only a small number of PSTs to be studied. Although detailed results are obtained on the change in argumentation, SSI related knowledge and PCK, these findings are only limited to the 16 PSTs who participated in this study. However, the qualitative nature of the study provides rich data and enables the researcher to explore the changes in argumentation skills, SSI-related knowledge and PCK in depth. Similar qualitative studies have been carried out by other researchers (Cinici, 2016; Pinzino, 2012). In addition, this study opens up opportunities for future studies which may involve more PSTs and research of other domains such as reasoning skills, decision making skills and problem solving strategies.

1.8 Definition of Terminologies

Argumentation: Argumentation in science education has been explained as a process of proposing, supporting, criticizing, evaluating, and refining ideas about a scientific subject" (Kuhn, 2010). It is the process of forming reasons, justifying beliefs, and drawing conclusions based on scientific knowledge. This study researched on the ability of PSTs in developing arguments over a series of SSIs. The arguments were presented in responding to the open-ended questions and interviews in the form of argumentations.

Argumentation Skills: Argumentation skills refer to the ability of the learners to present the arguments. In presenting the arguments the learners should be able to make and defend claims, scrutinize and provide evidence-based reasoning of a specific situation, idea or issue. In this study, argumentation skills are analysed based on Toulmin's Argumentation Pattern (TAP) that consists of six structural components: claim, data, warrant, backing, qualifier and rebuttal. The quality of argumentation skills is further determined by categorising these skills from level 1 to level 5 as proposed by (Erduran, 2007). Level 1 indicate the lowest level and level 5 indicates the highest level of argumentation.

Pedagogical content knowledge (PCK): PCK is a field of knowledge required by a teacher to understand how content knowledge can transform into instruction, and how the content knowledge is related to students' knowledge and ideas (Shulman, 2010).

PCK is the special knowledge used by a teacher to transform content knowledge to benefit students (Grossman, 1990). In this study, the acquisition of PCK about SSI-based projects explored based on three categories: curriculum, instruction and assessment.

PCK-Curriculum: The pre-service teachers' knowledge of pedagogical content knowledge is explored in the curriculum domain. Knowledge of curriculum in this study refers to knowledge of science curriculum specification for the STS subject (Magnusson, Krajcik, & Borko, 1999) and the knowledge of curriculum materials available for teaching the particular subject (Porter, 2002). Knowledge of curriculum materials refers to socio-scientific issues used in the teaching of the STS subject.

PCK-Instruction: The pre-service teachers' knowledge of pedagogical content knowledge is explored in the domain of instruction. Knowledge of instruction refers to the scaffolding prepared for learning by using SSI based projects. In this approach higher-order practices (Presley et al., 2013) such as analyzing and interpreting data, using evidence for reasoning and communicating information are emphasised. In addition, eliciting students' pre-requisite knowledge, discovering real-world patterns and the explanations for them that must be invented (Magnusson & Palincsar, 1995) and scaffolding student argumentation to explore alternative explanations are also emphasised.

PCK-assessment: Knowledge of assessment in this study refers to information that can be used as feedback by teacher educator, and the pre-service teachers, in assessing themselves and each other (Black, 2017). Activities that enable assessment such as discussions and working cooperatively in groups (Blatchford, Baines, Rubie-Davies, Bassett, & Chowne, 2006) were also explored. Baysura, Altun, & Yucel-Toy, (2016) defines PBL partially as having a process and product where learners are given; extending over a period of time; developing learners' understanding of a topic and collaborating with other learners and working on their own and reflecting on both the process and the product. In this study, the 8-step PBL model created by Pacific Education Institute (PEI) is used to incorporate SSI.

Progressive Exposure: Progressive means happening or developing gradually or in stages. Exposure means the experience of something (Oxford Dictionary, 2016). In this study, socioscientific issues were introduced progressively as the project in each topic was carried out. Pre-service teachers then experienced the instructions in SSI-based projects which are based on the respective SSI in each topic.

Socioscientific Issues (SSIs): SSIs involve the deliberate use of socially related scientific issues that require students to engage in dialogue, discussion, and debate (Zeidler, 2001). SSIs are usually controversial in nature, personally meaningful to learners and require evidence-based reasoning in the process of making decisions regarding possible resolution of the issues (Sadler, 2004; Zeidler & Keefer, 2003). In this study, the SSIs are local issues that are related to the STS topics and the PSTs are familiar with the issues. The issues covered in this study are as follows: accident involving a double-decker bus; water crisis in the world; the trapping of a wild tiger in a village; consumption of junk food by school students and leptospirosis.

SSI-based projects (SSIBP): SSIBP is the project-based learning model that has incorporated SSI in it. The 8 steps in SSIBPs are centred on the SSI in each topic. After set induction in step 1, SSI was introduced in step 2. During step 3, PSTs investigated the issue based problems and in step 4 they identified various solutions to issue-based problems through group discussion. In step 5 the PSTs collectively decided on one solution and in step 6 they justified their solution by working cooperatively in groups. In step 7, they drew up the solution and finally presented their solution to the class in step 8. The five SSIBPs in this study were prepared by the researcher by selecting a suitable SSI for each topic and planning further instruction based on each SSI.

SSI related knowledge: SSI related knowledge refers to the knowledge that the PSTs acquired when they were exposed to SSI based projects. The intended knowledge to acquire is the content knowledge that is related to the STS curriculum: factors affecting the stability of objects in Topic 1; process of water purification in Topic 2; energy flow in the biosphere in Topic 3; food processing method in Topic 4 and factors affecting pollution in Topic 5.

1.9 Summary

This chapter began by providing an overview of the study and a brief outline of teacher education and the importance of contemporary approaches to teaching science in Malaysia, particularly SSI-based instruction in a project-based learning approach. Subsequently, the important components of this study were discussed in this chapter inclusive of the problem statement, objectives of the study and research questions. Next, the significance and limitations of the study were presented. The chapter ended with the definition of terminologies used in this study.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This study is set at a period when Malaysia has only five years to realize its vision to be a fully developed nation, or vision 2020. The Malaysian Educational Blueprint (2013- 2025) emphasises 21st-century learning where one of the main components is project-based learning. As such, the science teacher education should produce pedagogically capable teachers who are able to critically apply science related issues that might arise in their everyday lives to enhance science content knowledge in their students.

Therefore, a section of this chapter is devoted to discussing the current teacher training program, its curriculum and the approaches in Malaysia, particularly the approach in teaching science, technology and society. The next sections of the literature review explore what are the ideas and benefits of SSI-based projects, its effect on pre-service teachers' argumentation, SSI-related knowledge and pedagogical content knowledge. This chapter is concerned with the review of writings, views, research reports and opinion of researchers in relation to the problem under discussion. It also contains the theoretical framework that highlights the psychological theories on which the study was grounded and justified.

2.1 Teacher Training Program and Science Teacher Training Curriculum

The Institute of Teacher Education (IPG) trains pre-service teachers (PSTs) who eventually will be teaching students from year one to year six in the primary schools in Malaysia. The IPG functions under the governance of the Ministry of Education (MOE). Currently, there are 27 Institute of Teacher Education in Malaysia. Students enroll for the teacher education program offered at IPG after completing their secondary education or Malaysian Certificate of Education (SPM). The selection for the teacher education program is made based on the students' SPM results whereby it is compulsory for the candidates to obtain a minimum of five distinctions in their SPM examination. Candidates then undergo a tedious selection procedure which includes an aptitude test, physical fitness test and face to face interview.

Selected candidates are then placed in the Bachelor of Education Preparatory Course (PPISMP) according to their majors. The preparatory course is carried out for a duration of two semesters. The curriculum structure of PPISMP is such that the subjects are divided into two main components: the core subjects and the generic subjects. At the preparatory level, 24 credit hours (48%) of the task time are allocated for core subjects and 26 credit hours (52%) for generic subjects. The core subjects for students majoring in science are physics, chemistry and biology. The generic components consist of subjects related to languages, moral and Islamic studies, learning skills, health and fitness and issues in education. The generic component is studied by all PPISMP students. However, the core subjects differ according to the students' majoring subject. Students majoring in science study physics, chemistry and biology as the core subjects and here science content knowledge is emphasised (MOE, 2014). Upon successfully completing PPISMP by passing all the subjects offered over a period of one year, students are then placed in the degree program known as Bachelor of Education Program (PISMP).

The PISMP requires PSTs to complete a total of 133 credit hours. These credit hours include 23 credit hours of compulsory subjects, 86 credit hours of major subjects which include school-based experience, practicum and internship and finally 24 credit hours credit hours of elective subjects (MOE, 2014). The PISMP study mode encompasses face to face interaction, tutorials and independent self-learning besides school-based experience, practicum and internship. During PISMP a total of 86 credit hours or 65% of the task time is allocated for learning science subjects. The science curriculum consists of 15 subjects that must be taken by the PSTs. These subjects include Life and living processes, Children's learning in science, Exploring materials, Primary science curriculum and pedagogies, Physics in context, Thinking and working scientifically, Ecosystem and biodiversity, Planning to teach in primary science, Energetics in chemistry, Earth and space, Evaluation in science teaching, Management of the science laboratory and resources, Action research and Science technology and society. Another 24 credit hours or 18% of the task time is spent learning elective subjects such as physical education and languages. PSTs have to pass all subjects taken to qualify to become a teacher who will be placed in the primary schools.

The PISMP curriculum is parallel to the primary science curriculum as PSTs have to thoroughly know the primary science curriculum when they undergo practicum and internship. The primary science curriculum is in line with the national philosophy of education where effort is made towards "further developing the potential of individuals in a holistic and integrated manner, in order to produce individuals who are intellectually, spiritually, emotionally and physically, balanced and harmonious, based on a firm belief in and devotion to God" (CDC, 2006). The national philosophy of science education resulted from the national philosophy of education which emphasises the nurturing of "Science and technology culture by focusing on the development of individuals who are competitive, dynamic, robust and resilient and able to master scientific knowledge" (CDC, 2006). In catering towards the needs of the 21st century, grounding on national philosophy of education and national philosophy of science education, a new Primary School Standard Curriculum (KSSR) has been formulated and implemented beginning from 2011.

With the implementation of KSSR, the teaching of science has been increasingly challenging. This is because one of the requirements of the curriculum is to incorporate higher order thinking skills (HOTS) into the teaching and learning of science (CDC, 2011). HOTS or generally known as 21st-century skills comprise of the ability to incorporate adaptability, complex communication skills and the ability to solve non-routine problems through teaching science. These abilities and skills are necessary to secure a good job as the workforce of the 21st century requires the HOTs and abilities. The ability to instill these abilities and skills would be made possible by the teachers having appropriate PCK. The pre-service teacher's curriculum is definitely a possible venue to educate the teachers on PCK.

An utmost imperative skill that the students should possess to master the 21st-century skills is the ability to argue (Osborne et al., 2004). As such the ability to argue and crafting effective arguments should be inherently taught in the science lessons. In other words, developing argumentation among the students should be an integral part of the pedagogy used in the classroom. Hence, in this study, an attempt will be made to educate pre-service science teachers on the role of SSI-based projects (SSIBPs) in enhancing argumentation skills. This is because previous studies have proposed that SSI-based instruction would be an effective means to deliver argumentation because of its multidisciplinary nature (Osborne et al., 2004). In the context of pre-service science teachers' curriculum implemented in IPG, the Science technology and society (STS) course is a possible platform to introduce SSIs to these PSTs. Therefore, SSIBPs will be integrated into teaching and learning of STS and the changes in argumentation skills, knowledge related to SSI and PCK of the PSTs will be explored.

2.2 Science Technology and Society

Science, technology and society (STS), is a branch of science studies that addresses the scientific, social, and economic needs of society so that learners are aware of the needs of the community to be able to participate in the technologically oriented economy (Driver, Newton, & Osborne, 2000). The STS approach uses multidisciplinary issues from various fields such as sociology, history of science and technology, politics, ethics, and psychology (Aikenhead, Fleming, & Ryan, 1987). For example, the teaching of STS explores the effect of water pollution on society and how the decision is made by the relevant authorities to restore the cleanliness of river water. Teaching STS enables learners to engage in meaningful learning which includes addressing discussion, argumentation, and problem-solving skills and then applying these skills to real-life situations (Tsai, 2002) and thus, STS enables scientific literacy for learners and is considered an important goal in science education (Hunter, Laursen, & Seymour, 2007).

STS has been given emphasis since the 1970s when science education researchers focused on developing a theme of study that reflected the combined