Chapter 3
Pre-service Secondary Science Teachers' Beliefs About Teaching Socio-scientific Issues

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3.1 Background

Scientifically literate individuals should not only have rich scientific knowledge but also be able to make informed decisions and participate in public debates on scientific issues. As a result, over the last few decades, there has been a call to address socio-scientific issues (SSI) in science education (e.g., Sadler 2011; Zeidler et al. 2005). Despite this growing advocacy for SSI teaching in secondary education, there is a gap between this theoretical ideal and the current practice of teachers. Although Hong Kong followed the science-technology-society (STS) movement in the 1980s and 1990s and integrated science-technology-society-environment (STSE) into secondary science curricula (Curriculum Development Council & Hong Kong Examinations and Assessment Authority 2017), SSI remain absent in the science curriculum and public examination of science. In contrast, SSI have found their place in Liberal Studies (LS), a core subject for all senior secondary students in Hong Kong. LS includes one particular Area of Study called Science, Technology and the Environment, in which one of the objectives is to enable students to 'be aware of the social, cultural and moral issues related to science, technology and the environment […] and […] to make judgements and informed decisions on [the issues]' (CDC & HKEAA 2015, p. 43). In this context it is not surprising that SSI teaching is rare, if not absent, in Hong Kong science education. However, while the extent to which relevant scientific knowledge and evidence are properly discussed in LS classrooms remains questionable, science teachers can contribute to the desired aims of SSI teaching in Hong Kong.

This study addresses the discrepancy between what the reform promotes (i.e., SSI teaching in secondary science education) and the reality in Hong Kong (i.e., the

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scarcity of SSI teaching in science classrooms) by focusing on pre-service science teachers. Our choice to focus on pre-service teachers (PSTs) was inspired by previous studies suggesting that less experienced teachers were more likely to use STS topics than their more experienced counterparts (Lumpe et al. 1998). Therefore, our study is situated in the context of a reform-oriented initial science teacher education course designed to improve pre-service science teachers' understanding of SSI. We believe that science educators should consider teachers' beliefs about the importance of teaching SSI to promote its implementation in science classrooms. As a result, the study examines PSTs' beliefs about the importance of SSI teaching in the local science curriculum and identifies their key learning experiences during the course. This information can help to improve not only our course design, but also that of other teacher education courses. The following research questions guided our study:

1. What were the PSTs' beliefs about the importance of SSI teaching in the science curriculum and the reasons for changing their beliefs, if any, after attending this course?
2. What did the PSTs find most impressive in this course to facilitate their learning about SSI teaching?

3.2 Theoretical Framework

In the following section, we first define SSI and emphasise their importance in the development of students' scientific literacy. We then present our rationale for focusing on PSTs' beliefs about SSI teaching in this study.

3.2.1 Socio-scientific Issues (SSI)

SSI refers to issues emerging from the interrelationship of science and society that are often factually and ethically complex, with no clear solution, subject to on-going inquiry and based on uncertain, fragile and conflicting evidence (Sadler 2004). An essential difference between SSI and STSE is that SSI pays attention to the ethical dimension of social issues with conceptual, methodological and/or technological links to science (Zeidler et al. 2005). Ratcliffe and Grace (2003, pp. 2–3) suggested that socio-scientific issues:

1. Have a basis in science, frequently that at the frontiers of scientific knowledge;
2. Involve forming opinions, making choices at personal or societal level;
3. Are frequently media-reported, with attendant issues of presentation based on the purposes of the communicator;
4. Deal with incomplete information because of conflicting/incomplete scientific evidence, and inevitably incomplete reporting;

5. Address local, national and global dimensions with attendant political and societal frameworks;
6. Involve some cost-benefit analysis in which risk interacts with values;
7. May involve consideration of sustainable development;
8. Involve values and ethical reasoning;
9. May require some understanding of probability and risk; and
10. Are frequently topical with a transient life.

Many studies have highlighted that teaching SSI can lead to desirable student learning outcomes, such as fostering critical thinking skills, decision making, argumentation, reflective judgement and moral development (e.g., Sadler 2004; Zeidler et al. 2011). More importantly, SSI teaching can help develop students' scientific literacy (Zeidler et al. 2005), which involves making informed decisions about SSI as a significant component (Zeidler 2014).

Roberts (2007) summarised various perspectives on scientific literacy and classified them into two main streams: *Vision I* and *Vision II*. *Vision I* explores science from an inward perspective, focusing on 'the products and processes of science itself' (p. 730). In contrast, *Vision II* adopts an outward approach by focusing on 'situations in which science can legitimately be seen to play a role in other human affairs' (p. 729) or 'character of situations with a scientific component, situations that students are likely to encounter as citizens' (p. 730). In other words, *Vision I* focuses on the understanding of science itself, while *Vision II* focuses on the role of science in human affairs, and there is a continuum between these two extremes.

Hodson (2003) suggested that '[t]raditionally, science education has dealt with established and secure knowledge, while contested knowledge, multiple solutions, controversy and ethics have been excluded' (p. 664). It is not surprising that many science teachers simply consider that their main task is to teach scientific principles and concepts, while any substantive pedagogical change is regarded as a burden (Lee and Witz 2009). However, given the complex, open-ended and value-laden nature of SSI and the involvement of values and ethical reasoning, addressing only *Vision I* in instruction is not enough to help students understand SSI.

3.2.2 Teachers' Beliefs About SSI

Teachers' beliefs play an important role in shaping teachers' practices in the classroom (e.g., Bryan and Atwater 2002; King et al. 2001). Lee and Witz (2009) indicated that teachers may choose to discuss SSI because of their beliefs and values. Several studies have investigated teachers' beliefs about the importance of teaching SSI. Kara (2012) examined the perceptions of 102 pre-service biology teachers in Turkey on SSI teaching using a questionnaire they designed. It was revealed that PSTs of biology generally believed that SSI should be taught in biology classrooms. In a similar study involving 37 science teachers in the US, Pedersen and Totten (2001) found that although teachers thought it was important to teach social issues in science classrooms, only some believed that teaching social issues was as important as teaching science content. In a more recent qualitative study, Tidemand and Nielsen (2017) examined Danish biology teachers' beliefs about the role and function of SSI teaching activities for biology teaching in upper secondary schools. The authors revealed that teachers tended to have a content-centred interpretation of SSI, as evidenced by their use of SSI as an instrument to engage and facilitate students' learning of content knowledge. Only a few teachers taught SSI to prepare students to deal with issues outside of school.

We believe it is essential for PSTs to develop their beliefs about the importance of teaching SSI. As a result, we examine their beliefs about the importance of SSI in the science curriculum and their underlying reasons, using a course focusing on SSI. We expect the position of SSI teaching in the science curriculum to reflect the importance of SSI in science education, in turn affecting *whether* and *how* SSI should be implemented in science classrooms.

3.2.3 Course Design

The course adopted a reflection orientation in its conceptualisation (Abell and Bryan 1997). Participants were frequently invited to reflect on their learning experiences during the course by writing a reflective journal. The course consisted of three modules over 12 weeks (24 contact hours). In terms of content, the course focused on improving PSTs' NOS conceptions including the epistemological and sociological aspects of science (McComas 1998), their understanding of SSI (Ratcliffe and Grace 2003) and the intertwining nature of NOS and SSI. The focus on both NOS and SSI was informed by previous studies suggesting that NOS provided students with relevant conceptual tools to critically examine specific SSI (e.g., Khishfe 2012; Leung et al. 2015) and that SSI served as an effective context to improve students' conceptions of NOS (Sadler et al. 2004). As a result, our design echoed Karisan and Zeidler's (2017, p. 148) suggestions that '[g]iven the corpus of research around NOS and SSI (Zeidler 2014), we also suggest that teacher training programs should be reformed to include the integration of NOS in the context of SSI'. In terms of pedagogical approach, the course intended to foster PSTs' learning through reflection from a learner perspective and a teacher perspective, as detailed below.

(1) **Reflection from a learner perspective.** We reproduced Demirdöğen, Hanuscin, Uzuntiryaki-Kondakci and Köseoğlu's (2016) pedagogical approach to teach NOS to improve PSTs' NOS conceptions and their instructional repertoires. Specifically, we adopted an explicit reflective approach (Abd-El-Khalick and Lederman 2000) and used activities, such as Post box activities (Hume 2009), to help students reflect on their new understanding of NOS. The instructors modelled how to run a debate session about nanofood, which engaged participants in socio-scientific reasoning (Sadler et al. 2017) and argumentation discourse.

(2) **Reflection from a teacher perspective.** We also explicitly addressed NOS and SSI from a teacher perspective. For instance, in Module 3, instructors discussed with students the principles and strategies of developing scientific literacy using news media in the classroom following Jarman and McClune (2007). Module 3 also included two instructional sessions with video analysis of authentic video footage featuring SSI and NOS teaching in Hong Kong classrooms (Yip et al. 2018). Table 3.1 summarises the structure, key ideas and activities adopted in the course.

3.3 Methods

The study used a qualitative case study approach (Merriam 2009). Eighteen PSTs (nine females and nine males (pseudonyms used below)) enrolled in the final year credit-bearing course entitled *Nature of Science and Socio-scientific Issues* voluntarily participated in the study.

3.3.1 Data Collection

Change in Teachers' Beliefs About SSI The following three questions were extracted from the written survey on Pedagogical Content Knowledge about Socio-scientific Issues (PCK-SSI) (Tosunoglu and Lederman 2016) administered immediately before the Module on *SSI as learners* in Week 5 to document participants' beliefs about SSI teaching:

1. Should SSI teaching be a part of the science curriculum?
2. Do you think that emphasizing SSI in the science curriculum is necessary? (If yes, why? And if no, why (not?)?)
3. Do you believe it is important to spend instructional time in your science classroom to teach students about SSI? (If yes, why? And if no, why not?)

Table 3.1 Summary of topics in each module

Weeks	Module	Key ideas	Pedagogical activities
1–4	1. NOS as learners	NOS: A philosophical, epistemological and socio-cultural perspectives	Post box activities
			Interactive discussion
5–8	2. SSI as learners	The nature of SSI; socio-scientific reasoning and synthesis of ideas and practices	Emergent graphical interpretation
			Interactive discussion
			Peer debate
9–12	3. NOS and SSI as teachers	The use of media for teaching; pedagogy and assessment of NOS and SSI	Interactive discussion
			Video analysis

At the end of the course, as part of their assessment, participants wrote an essay with the following instruction:

> In light of the latest developments in the local science curriculum, identify the components (e.g., science content knowledge, NOS, SSI) that you consider essential. Rank these components according to their level of importance and present your arguments in the form of a written essay.

The essays reflected their beliefs about the importance of the different components of the local science curriculum and the reasons for their beliefs. It is worth noting that participants did not necessarily include SSI as an essential component of the science curriculum. In any case, their reasons allowed us to explore their views and reasoning about SSI teaching in relation to other aspects of the science curriculum.

Key Learning Moments Participants kept a reflective journal to record their thoughts about SSI and its teaching and its change (if any) as well as their key learning moments after each module. The relevant parts of the journals (i.e., Modules 2 and 3) were used as the data source.

3.3.2 Data Analysis

The data collected were analysed qualitatively using open coding (Creswell 2008). The three authors reviewed the data corpus independently before meeting to discuss the initial codes and develop the consensus codes. The first author then re-read each student's responses and assigned codes to the data. The team re-examined the data with assigned codes until a consensus was reached. Validation strategies (Creswell 2007), such as investigator triangulation and frequent peer debriefing between the co-authors, were used to ensure the trustworthiness of the results. The following section describes in detail the analysis of the main constructs of the study.

Teaching Beliefs About SSI We analysed participants' responses to the PCK-SSI questionnaire, which was administered immediately before Module 2 to capture the influence of SSI-related Modules on PSTs' beliefs about SSI teaching (referred to as *pre-course* thereafter), and their written essays (post-course), which focused on their beliefs about the importance of SSI teaching in the science curriculum and their underlying reasons. As the analysis progressed, three categories of participant views, namely *instrumental view*, *beyond an instrumental view* and *others*, emerged. This classification was informed by the literature and an interaction with the data. The term *instrumental* was borrowed from Tidemand and Nielsen (2017) and described the use of SSI teaching activities as an *instrument* to motivate, frame or put into perspective the teaching of a given science content. The use of this term resulted from a content-centred interpretation of SSI teaching by teachers. As a result, *instrumental view* included the use of SSI to (1) motivate and stimulate students' interest in science learning (*motivation and interest*), (2) apply science content knowledge to real life (*knowledge application*), and (3) *facilitate the learning*

Table 3.2 Classification of teaching beliefs about SSI

Categories	Sub-categories	References
Instrumental view	Motivation and interest	Tidemand and Nielsen (2017)
	Knowledge application	Tidemand and Nielsen (2017)
	Facilitating learning of science content	Sadler et al. (2016)
Beyond an instrumental view	Citizenship education	Vesterinen et al. (2016)
	As a context for teaching NOS	Karisan and Zeidler (2017)
	Skill development (e.g., critical thinking skills, decision-making, argumentation, reflective judgement and moral development)	Sadler (2004) and Zeidler et al. (2011)
	Values education	Lee et al. 2013
	Development of scientific literacy	Zeidler et al. (2005)

of science content. Conversely, *beyond an instrumental view* referred to the use of SSI teaching activities for purposes other than acquiring content knowledge, e.g., *skill development*, *as a context for teaching NOS*, *citizenship education* and the *development of scientific literacy* (see Table 3.2).

Key Learning Moments The classroom activities perceived as useful by the participants for their learning and how these activities supported their learning, as illustrated by their reflective journals, were analysed qualitatively. The key learning moments relevant to SSI teaching were identified and categorised according to their primary focus, SSI from a learner perspective and SSI from a teacher perspective.

3.4 Results and Discussion

In this section, we first report the results of the pre-course and post-course participants' beliefs about the importance of SSI teaching in the science curriculum and their reasons for incorporating (or not) SSI into the curriculum (RQ1). We then provide an overview of the key learning moments identified by the participants and how these classroom activities contributed to their learning (RQ2).

3.4.1 Pre-course Teaching Beliefs About SSI

As shown in Table 3.3, all participants agreed that SSI teaching should be part of the science curriculum. Of the 18 participants, 15 agreed on the importance of emphasising SSI and 16 on spending instructional time on SSI teaching. Contrary to the

Table 3.3 Participants' beliefs about the importance of SSI in the science curriculum

	No. of participants		
	Agree	Disagree	Indecisive
SSI should be part of the science curriculum	18	0	0
SSI should be emphasised in the science curriculum	15	3	0
It is important to spend instructional time on SSI	16	1	1

majority view, three participants disagreed that the science curriculum should emphasise SSI and one did not consider it important to devote instructional time to SSI. The underlying reasons are discussed later.

Table 3.4 presents the reasons given by the participants for integrating SSI into the curriculum. Their views can be classified as follows: (1) *instrumental view*, (2) *beyond an instrumental view* and (3) *others*. For *instrumental view*, 6, 4 and 2 out of the 18 participants considered that SSI could offer opportunities to apply scientific knowledge, boost motivation and interest in science learning and facilitate science learning, respectively. In addition, 8 and 5 out of the 18 participants held a *beyond an instrumental view*, perceiving SSI as a context for learning NOS and developing skills. Some participants proposed reasons that could be classified as an *instrumental view* and *beyond an instrumental view* (e.g., Cheryl, Rick and Winnie), indicating that these two views were not mutually exclusive. Unlike Tidemand and Nielsen's (2017) results on in-service teachers which indicated the high prevalence of *instrumental view* among in-service teachers, only 6 out of the 18 participants gave reasons classified only as an *instrumental view*. This result may be attributed to the focus on SSI and NOS in this course. The two participants (Ian and Lillian) belonging to *others* proposed that Hong Kong should follow the global trend of SSI teaching and supported their beliefs with reasons classified as an *instrumental view* or *beyond an instrumental view*.

Due to the lack of explicit focus on SSI in the public examination, Joyce, one of the three participants, did not consider it necessary to focus on SSI. Her statement clearly illustrated her view:

> I think focussing on NOS and SSI in the science curriculum is not necessary, unless there is a corresponding assessment reflecting students' understanding of them… If the curriculum emphasises NOS and SSI but the hard work of teachers and students cannot be objectively reflected, this may mislead teachers when planning their lessons.

Rick shared a similar view with Joyce, albeit being more optimistic. He contended that SSI should be emphasised in the curriculum and the public examination so that teachers and students would be motivated to teach and learn about SSI. His view was reflected in the following statement:

> … emphasising NOS and SSI in the curriculum can encourage teaching and learning about these elements. Due to public examination rewards, teachers are more likely to incorporate NOS and SSI into their teaching, while students are more motivated to learn them.

Keith echoed Rick's suggestion that SSI should be emphasised in the science curriculum, but admitted that little instructional time could be spent on SSI due to their low importance in the public examination, as illustrated by his statement: 'I

Table 3.4 Pre-course reasons for integrating SSI teaching into the science curriculum

Reasons	No. of participants	Participants	Sample excerpts
Instrumental view			
Knowledge application	6	Cheryl[a], Ian[b], Keith, Lillian[c], Rick[a], Winnie[a]	*SSI is important to prepare students to apply scientific knowledge in society* (Keith).
Motivation and interest	4	Gladys, Ian[b], Sam, Wilson	*As SSI topics are interesting and relatable to students' lives, they can also encourage students to pursue scientific knowledge* (Sam).
Facilitating science learning	3	Daniel, Gladys, Winnie[a]	*SSI refers to controversial social issues related to science… Therefore, SSI provides a ground for an open-ended discussion to facilitate students' learning and understanding of science* (Winnie).
Sub-total	10		
Beyond an instrumental view			
As a context for NOS	8	Bianca, Charles, Cheryl[a], Ian[b], Joyce, Morris, William, Winnie[a]	*SSI is one of the tools with which students can apply their understanding of NOS and teachers can assess students' understanding or beliefs about NOS* (William).
Skill development	5	Anastasia, Rick[a], Tiffany, Wendy, Winnie[a]	*SSI encourages students to practise moral reasoning and critical thinking… The skills they acquire in science class, like critical thinking and reasoning, will also be applicable in the future* (Anastasia).
Sub-total	12		
Others			
Global trend	2	Ian[a], Lillian[b]	*NOS and SSI are part of the science curriculum of many countries. Therefore, they can be considered an essential part of science education* (Lillian).
Sub-total	2		

Note: [a]Participants holding an *instrumental view* and *beyond an instrumental view*; [b]participants holding an *instrumental view, beyond an instrumental view* and *others*; [c]participants holding an *instrumental view* and *others*

will definitely discuss SSI with my students, but as usually less than 5% of the public examination questions are about SSI, I will probably spend little time on it…'

His view was consistent with previous studies on in-service teachers suggesting that lack of instructional time for content with little or no coverage in examinations was often perceived as a barrier to SSI teaching (Lee et al. 2006). Given the exam-oriented culture in Hong Kong, participants indicated that they generally focused on preparing students for public examination, which put heavy weighting on content knowledge. In other words, their motivation to teach SSI depended largely on the curriculum and the weighting of SSI in the public examination. This result suggested that in the absence of curriculum and assessment reform, science teachers would have little or no incentive to teach SSI.

3.4.2 Post-course Teachers' Beliefs About SSI

At the end of the course, 17 out of the 18 participants considered SSI as one of the important components of the science curriculum (see Table 3.5). Of these 17 participants, 9 prioritised content knowledge (CK) over SSI in the science curriculum, placing them nearer to *Vision I* than *Vision II*. In contrast, the remaining 8 participants prioritised SSI over CK in the science curriculum, placing them nearer to *Vision II* than *Vision I*.

As shown in Table 3.6, 15 out of the 18 participants gave reasons justifying their prioritization of SSI teaching in the science curriculum. While only 4 proposed reasons indicative of an *instrumental view*, all these 15 participants proposed reasons classified as *beyond an instrumental view*, compared with 12 in the pre-course stage. In other words, none of them held a purely *instrumental view*, compared with 6 participants in the pre-course stage. These results suggested a shift from an *instrumental view* to one that went beyond it.

Table 3.5 Participants' ranking of the components of the science curriculum according to their level of importance

Ranking	1	2	3	4	5
Vision I-oriented					
Daniel	CK	NOS	SSI	–	
Morris	CK	NOS, SI and SL	–	–	SSI and STSE
Rick	CK	NOS	SSI	–	–
Sam	CK	NOS	SSI		
Wilson	CK	NOS	SSI	–	–
Keith	CK, NOS, STSE	–	–	SSI	–
Winnie	NOS	CK	SSI	–	–
Bianca	SL	CK	SI	NOS	SSI
Anastasia	STEM	NOS	CK	SSI	–
Vision II-oriented					
Charles	SSI	SI	NOS	CK	–
Cheryl	SSI and SI	–	NOS	CK	
Gladys	STSE	NOS, SSI	–	SI	CK
Lillian	STSE	NOS	SSI	–	–
William	SI	SSI	Unifying concepts	NOS	–
Tiffany	STEM	NOS, SSI	–	–	–
Wendy	STEM	NOS, SSI	–	CK	–
Ian	STEM	NOS	SSI	CK	–
Other					
Joyce	Scientific investigation	NOS	Information literacy	–	–

Note: *NOS* (nature of science), *SI* (scientific inquiry), *SL* (scientific literacy), *CK* (content knowledge), *SSI* (socio-scientific issues), *STEM* (science-technology-engineering-mathematics), STSE (science-technology-society-environment)

Based on their view of scientific literacy, participants were further categorised into three groups, namely *Vision I*, *Vision II* and *Others* (i.e., ranking neither SSI nor CK as an important component of the science curriculum). According to this categorisation, their proposed reasons for the importance of SSI in the curriculum were presented in an attempt to compare these reasons with their view of scientific literacy. Seven of the nine participants in the *Vision I* group and all eight participants in the *Vision II* group gave reasons to prioritise SSI teaching (see Table 3.6). For *beyond an instrumental view*, in addition to reasons related to skill development and as a context for NOS, three new supporting reasons were proposed, namely *citizenship education*, *values education* and the *development of scientific literacy.* It is worth noting that three quarters of *Vision II* participants prioritised SSI teaching for citizenship education, compared with just over a fifth of *Vision I* participants. This difference can be attributed to the alignment of citizenship education with their teaching beliefs.

Further examination of the different responses revealed some possible reasons why SSI should *not* be prioritised in the science curriculum. Consider Morris' response:

> Although SSI and STSE in the science curriculum can develop students' positive attitude towards the contribution of science to socio-scientific issues, covering SSI and STSE in detail in science class is challenging for teachers because of the complexity of the different issues.

The above excerpt highlighted the first reason – *the complexity of SSI and the associated challenges*. This view was consistent with previous studies on in-service teachers, which discussed the challenges faced by teachers in SSI teaching, including lack of knowledge about SSI, uncertainty about how to conduct controversial discussions and how to manage lessons using small-group discussions, role playing and similar teaching strategies (Bryce and Gray 2004; Lee et al. 2006). Science teachers in Hong Kong are used to teaching CK, which usually has absolute answers. Therefore, this result suggested that it would be a challenge for them to teach SSI, which is more complex, open-ended and value-laden.

Another reason specific to the Hong Kong context emerged, represented by the following excerpt from Keith:

> SSI may be less important due to the presence of LS, which is a core subject in the local curriculum […] LS teachers may further 'connect knowledge and concepts across different disciplines' (CDC & HKEAA 2015) and this may provide a more well-rounded training than the SSI approach…

Keith's statement clearly illustrated the second reason – some participants believed that it would be *more appropriate to teach SSI in other subjects* (e.g., LS in the Hong Kong curriculum context). This view echoed previous findings from studies involving in-service teachers (Tidemand and Nielsen 2017). Although the current literature has largely corroborated these two reasons, we found a unique reason, as evidenced by Rick's statement: '[t]he reason for SSI's low ranking is that negotiating SSI somehow depends on science CK and understanding of NOS'. Rick believed in the more fundamental role of CK and NOS in supporting SSI negotia-

Table 3.6 Post-course reasons for prioritising SSI teaching

Reasons for prioritising SSI teaching	Number of participants (n = 15)				Excerpts
	Vision I (n = 9)		*Vision II* (n = 8)		
Instrumental view					
Knowledge application	2	Anastasia, Sam	2	Cheryl, Gladys	*… the integration of SSI in the curriculum… allow[s] students to make good use of scientific knowledge relevant to society…* (Anastasia, *Vision I*)
Sub-total	2		2		
Total	4				
Beyond an instrumental view					
Citizenship education	2	Anastasia, Rick	6	Cheryl, Charles, Gladys, Ian, Lillian, Wendy	Holbrook (2008)[1] *argued that based on the introduction of conceptual science, student enhancement of scientific literacy needs to consider a societal frame and to embrace the socio-scientific situation that provides the relevance for promoting responsible citizenship* (Wendy, *Vision II*).
Skill development	4	Anastasia, Daniel, Sam, Wilson	3	Cheryl, Gladys, Ian	*SSI can help students… make decisions based on evidence and help them think critically and consider moral and ethical reasoning* (Bybee et al. 2009)[2] (Sam, *Vision I*).
As a context for NOS	3	Anastasia, Wilson, Winnie	3	Gladys, Tiffany, William	*… what makes SSI irreplaceable is how they incorporate multiple outcomes, for example, scientific literacy and the nature of science, also referred to as its 'unification power'* (Zeidler et al. 2005)[4] (Anastasia, *Vision I*).
Development of scientific literacy	4	Anastasia, Bianca, Daniel, Rick	1	Tiffany	*Negotiating SSI in a science classroom can provide valuable experience for students to critically evaluate the arguments of different stakeholders and ultimately determine their own position in a complex situation. This is consistent with Vision II in scientific literacy* (Roberts 2007),[3] *which is related to literacy in science-related situations* (Rick, *Vision I*).
Values education	2	Winnie, Wilson	0	–	*SSI… plays an important role in the formulation of students' personal values in science education, as it offers students an opportunity 'to develop their personal values'… and 'judgements'…* (Wilson, *Vision I*)
Subtotal	7		8		
Total	15				

tion. More importantly, his statement emphasised his limited view of a *unidirectional* relationship between CK and NOS to help students negotiate SSI without realising how SSI could help CK and NOS learning in an intertwining manner.

Daniel's statement also reflected a similar belief: '[a]s SSI can be perceived as a context, it can be incorporated into other components, and there is no pedagogical need to teach and learn about SSI in a separate, decontextualised way. Daniel suggested that SSI should be viewed as context rather than content. Nevertheless, unlike Rick, Daniel recognised the role of SSI as a context for other components (e.g., CK and NOS). Yet, it is noteworthy that he did not seem to recognise how CK and NOS facilitated the negotiation of SSI. In both cases, participants did not seem to come to grips of addressing the *interrelationship* between SSI and other components (e.g., CK and NOS) in the curriculum. Both Rick and Daniel belonged to the *Vision I-oriented* group, yet Lillian, who belonged to the *Vision II-oriented* group, had a different opinion. She aptly pointed out that 'SSI serves as the context to help students learn about NOS […] However, this is not a *unidirectional* facilitation but a *bi-directional* interaction […] meaning that one always provides opportunity to better understand the other'. This argument suggested an association between understanding the interrelationship between SSI and other components in the curriculum (e.g., NOS) and prioritising SSI teaching in the science curriculum.

3.4.3 Key Learning Moments

The two SSI-related Modules involved classroom activities identified as key learning moments for participants as individuals (See Table 3.7).

First, for *SSI from a learner perspective*, participants perceived that understanding the *nature of SSI* was important to their learning journey. By understanding the complexity of SSI, Morris became more aware of the challenges associated with SSI learning and teaching. This drew his attention to the need for more thoughtful planning for SSI teaching:

> … the differences between social issues and SSI were identified through classroom activities, which will help me explain the characteristics and importance of SSI to students when

Table 3.7 Summary of key learning moments

Categories	Topics	Classroom activities generating key learning moments
Module 2: SSI from a learner perspective	Nature of SSI: SSI vs LS; SSI vs pseudoscience	Interactive discussion
	Socio-scientific reasoning	Emergent graphical interpretation
	Synthesis of key ideas and practices	Peer debate
Module 3: SSI from a teacher perspective	Pedagogy of SSI	Video analysis

> teaching SSI in the future. I realised that the complexity of SSI creates barriers not only for students learning about SSI, but also for teachers discussing SSI. Therefore, I will need to think of ways to effectively teach and address SSI in science class to facilitate SSI learning for students…

Second, participants appreciated the class discussion on the differences between SSI teaching in science class and LS class, which offered them a platform to reflect on these differences. Understanding these differences helped participants build their identity as science teachers and recognise their unique role in student learning, as illustrated by the following excerpt:

> the class discussion on mad cow disease reminded me of the complexity and difficulty of talking about SSI and prompted me to think about how to approach the SSI discussion in my science class. Comparing the approach to SSI in LS class and science class, the main difference is that we use rigorous scientific reasoning and apply scientific knowledge more extensively in science classes. This difference is what I will emphasise in my future teaching (Bianca).

Third, participants valued the discussion on pseudoscience. Although science majors, it did not occur to the participants that some people could actually consider global warming as a fallacy, as indicated by Bianca's statement excerpt: '… we watched a video on the credibility of global warming […] I was astonished that some people actually argue that global warming is a fallacy, while for me global warming is an absolute truth'. This warned Bianca that students might not always share the same beliefs as most scientists, which made her aware of the need to explicitly explain to students the differences between scientific claims and pseudoscientific claims.

Fourth, participants identified the emergent graphical interpretation of socioscientific reasoning as a key learning experience, as indicated in the following excerpt from Bianca's statement:

> …there was a noticeable moment when some of us had problems with the interpretation of the graph on global energy. Never before did I have difficulty reading graphs, because my teachers always analysed the information for us and gave us the essential ideas. Therefore, I realised that I was too comfortable with my current method of dissemination. If I want to develop students' critical thinking and problem-solving skills, then I will have to think more about how to use the materials.

Graphs without full information posed challenges in terms of their interpretation and prompted Bianca to think about how to use graphs in her teaching, especially to develop students' critical thinking and problem-solving skills.

Fifth, for peer debate, consider the following statement written by Sam in his reflective journal:

> Before this Module, I had *little incentive to spend time discussing SSI* during my lessons because SSI was rarely assessed in the public examination. Triggered by the in-class debate experience, I found that *participating in SSI teaching is very different from acquiring scientific knowledge* […] I believe that discussing SSI can develop students' scientific literacy. On the one hand, students may have *a better understanding of the scientific concepts* involved by learning from nanomaterials. On the other hand, students may *acquire the ability to interpret and evaluate scientific information* to make an informed decision.

As a result of his participation in the debate, Sam realised that learning about SSI not only promoted the acquisition of CK, but also the skills of interpreting and evaluating scientific information. After the debate, he was motivated to spend time discussing SSI with his students. In other words, participating in SSI debates as learners gave participants first-hand experience in SSI learning, especially in terms of potential learning outcomes.

During the Module on *SSI from a teacher perspective,* video analysis was identified as a learning activity creating key learning moments, as illustrated by Lillian's statement:

> I found this Module very useful because it allowed me to understand the importance of teachers to facilitate student learning and develop their reasoning skills, which will be beneficial throughout their lives to make better judgements and decisions in the future.

The video analysis of SSI teaching emphasised various SSI teaching strategies, but also explicitly identified the goals of SSI teaching (e.g., developing reasoning skills).

These results highlighted key learning experiences from the perspective of participants, with some relevant experiences for their change of beliefs about SSI teaching (e.g., acknowledging the role of SSI teaching in skill development) and others with implications for their implementation of SSI teaching (e.g., recognising the complex nature of SSI).

3.5 Implications for Teaching and Research

The following section summarises the key findings of our exploratory attempt to promote SSI teaching in Hong Kong classrooms by addressing PSTs' beliefs about SSI teaching in a teacher education course:

- Participants' beliefs about SSI teaching shifted from an *instrumental view* to one that went *beyond an instrumental view* after the course;
- The *Vision II-oriented* group was generally better able to identify citizenship education as one of the 'good reasons' for prioritising SSI teaching in the science curriculum;
- The *Vision I-oriented* group tended not to give priority to SSI teaching for the following reasons: (1) the complexity of SSI teaching; (2) the shared curricular objectives of other subjects; and, (3) the subsidiary role of SSI to CK and NOS;
- The following key learning experiences were identified as essential: (1) in-class discussion about the nature of SSI; (2) emergent graphical interpretation for SSI reasoning; (3) peer debate for synthesising key ideas and practices; and (4) video analysis workshop on SSI pedagogy.

Our analysis of why PSTs do not prioritise SSI teaching helps us understand why they struggle to recognise the importance of SSI teaching in the curriculum. One possible reason is their limited understanding of the relationship between SSI, CK and NOS. For instance, some PSTs held a belief indicative of a *unidirectional* relationship between SSI, CK and NOS (e.g., SSI as a vehicle for teaching CK and NOS), ignoring the effects of CK and NOS on SSI teaching (e.g., CK and NOS as conceptual tools to support student argumentation and decision-making related to SSI). Although previous studies have demonstrated the close *interrelationship* between SSI and NOS (Karisan and Zeidler 2017) and between SSI and CK (Sadler and Zeidler 2005), our results highlighted the importance of addressing the *interrelationship* between SSI, CK and NOS in initial teacher education courses aimed at preparing PSTs for SSI teaching. Otherwise, PSTs may continue to see SSI as subsidiary to CK and NOS, affecting in turn whether and how SSI is implemented in science classrooms.

Although our results were based on a single secondary science education programme, limiting their generalisability to other contexts, our findings and insights are of direct concern and relevance to science educators working with PSTs to promote SSI teaching. The results inspired us, as teacher educators, to think critically about course design to identify areas that could be improved for other teacher educators. Similar to NOS teaching, our data led us to speculate that an explicit approach may be more effective in developing a *beyond an instrumental view* on SSI teaching. For instance, engaging PSTs in debates on *why* SSI should be taught will allow us to better identify their intuitive views on SSI teaching. This explicit reflective instruction may also draw PSTs' attention to the *interrelationship* between SSI, NOS and CK. As the current study focused only on PSTs' beliefs about SSI teaching, future studies might usefully explore how PSTs translate their beliefs into their instructional practices by focusing on how they plan and implement SSI teaching in their classroom instruction.

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