Exploring Indonesian Biology Teachers’ Perceptions and Attitudes Towards Socio-Scientific Issues-Based Instruction

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Abstract

Socio-scientific issues (SSIs)-based instruction is considered a potentially useful pedagogical approach for helping teachers to address the scientific literacy competencies outlined in the national curriculum. However, its effective implementation in the classroom requires teachers to have adequate pedagogical knowledge and skills. In this study, we engaged 45 pre- and in-service biology teachers in an 8-week SSIs teaching-oriented course. The course was designed to provide teachers with theoretical knowledge and practical SSIs teaching experience. Using data collected from the SSIs-based instruction questionnaire, interviews, and course assignments, we explored teachers’ perceptions and attitudes towards SSIs-based instruction. The results of quantitative and qualitative analysis indicated that teachers had a high awareness of some core aspects of SSIs-based instruction and perceived themselves as having sufficient knowledge about SSIs pedagogical aspects. Teachers also demonstrated positive attitudes and perceptions about SSIs-based instruction. However, teachers still recognized the challenges of the SSIs teaching implementation for biology teachers in Indonesian school contexts. Teachers considered factors such as curriculum requirements,
teachers’ competency, and students’ characteristics as the SSI teaching challenges. In addition, teachers expressed concerns about their capacity in managing the SSI discussion activities.

Abstrak

Pembelajaran berbasis isu-isu sosio-ilmiah (ISI) dianggap sebagai pendekatan pedagogis yang dapat mendukung guru dalam mengembangkan kompetensi literasi sains seperti yang ditetapkan pada kurikulum nasional. Namun, untuk menerapkan pembelajaran ISI yang efektif di kelas, guru diharuskan memiliki pengetahuan dan keterampilan pedagogis yang memadai. Dalam penelitian ini, kami melibatkan 45 guru dan calon guru biologi pada mata kuliah yang berorientasi pengajaran SSI selama 8 minggu. Mata kuliah ini dirancang untuk memberi guru pengetahuan teoretis dan pengalaman praktis dalam mengajarkan ISI. Dengan menggunakan data yang dikumpulkan dari kuesioner, wawancara, dan tugas mata kuliah, kami menguji dan mempersepsi serta sikap guru terhadap pembelajaran berbasis ISI. Hasil analisis kuantitatif dan kualitatif menunjukkan bahwa guru memiliki kesadaran yang tinggi terhadap beberapa aspek inti dari pembelajaran berbasis ISI dan mempersepsi diri mereka memiliki pengetahuan yang cukup tentang aspek pedagogis dari ISI. Guru juga menunjukkan sikap dan keyakinan positif tentang pembelajaran berbasis ISI. Namun, guru juga menyadari tantangan penerapan pembelajaran berbasis ISI bagi guru-guru biologi di sekolah. Guru mempertimbangkan faktor-faktor seperti persyaratan kurikulum, kompetensi guru, dan karakteristik siswa sebagai tantangan pembelajaran ISI. Selain itu, guru juga menunjukkan kekhawatiran tentang kapasitas mereka dalam mengelola kegiatan diskusi terkait ISI.

Keywords

biology teacher – attitudes – perceptions – teaching practice – socio-scientific issues – professional development

1 Introduction

In Indonesia, scientific literacy has been a major goal of the school science curriculum (MOEC, 2016). To achieve this goal, however, teachers need appropriate teaching resources. Previous studies in science education have
documented that instruction based on socio-scientific issues (SSIs) is a pedagogical approach that has the potential to improve students’ scientific literacy competencies (Ratcliffe & Grace, 2003; Zeidler, 2014). SSIs have been defined as complex societal issues with conceptual, procedural, and/or technological associations with science (Sadler et al., 2016). Already, a few SSIs-based instruction models have been advanced, presenting key elements and frameworks to integrate SSIs into science learning (Presley et al., 2013; Sadler et al., 2017; Friedrichsen et al., 2016).

Research has also revealed a range of challenges involved in SSIs teaching that may hinder teachers from implementing SSIs teaching. Among these are challenges related to the curriculum demand for focusing on the subject content (Tidemand & Nielsen, 2017), uncertainty in discussing value-laden issues (Sadler et al., 2006), and a lack of SSIs teaching resources (Saunders & Rennie, 2013). Many teachers also expressed concerns about their limited capacity to manage SSIs classroom discussions (Lee & Yang, 2019) and appropriately select a useful SSIs-related topic (Borgerding & Dagistan, 2018).

In this study, we designed and implemented a science methods course to address SSIs-based instruction to be implemented in a science teacher education program for biology teachers in Indonesia. We selected a graduate program in biology education at teacher education institution (TEI) as a suitable setting for this study. The more flexible curriculum in graduate programs allowed us to design and integrate content related to SSIs teaching and learning. In this course, pre- and in-service biology teachers were able to explore the conceptual framework and practical implementation of SSIs teaching and learning. Another consideration in selecting a research setting in graduate programs of TEIs was that much of the literature in both international and domestic Indonesian science education research on effective SSIs teaching and learning has been focused primarily on K-12 school contexts, while little research has addressed pre-service and in-service teacher participation in SSIs teaching-oriented courses at the university level. This study seeks to fill a gap in the literature about teachers’ perceptions about and attitudes towards SSIs teaching and learning.

Specifically, this study aimed to better understand Indonesian biology teachers’ perceptions and attitudes towards SSIs-based instruction as they engaged in an SSIs teaching-oriented course. Examining teachers’ perceptions and attitudes will inform their awareness of the SSIs educational framework. This study will contribute to the international literature by expanding what is currently known about how teachers view SSIs in different educational contexts. The findings of this study will also help to establish SSIs-based research as a topic of study in the Indonesian context and will provide implications for
science teacher educators in Indonesia and in countries with comparable educational contexts about how to effectively prepare science teachers to employ SSI-based instruction in schools.

The research question framing this study was:
1. How do biology teachers engaged in an SSI teaching-oriented course perceive SSI-based instruction?
2. What are biology teachers’ attitudes toward SSI-based instruction after participating in the SSI teaching-oriented course?

2 Review of Literature

In this section, we describe the conceptual framework used to develop the scales of the socio-scientific-issues (SSI)-based instruction (BI) questionnaire we developed and used to measure teachers’ perceptions and attitudes. We found it is important to frame the literature review of the issues related to SSI-based instruction into categories that consist of (1) core aspects of SSI-based instruction, (2) challenges of the implementation, (3) pedagogical knowledge, and (4) attitudes and beliefs about SSI-based instruction. These four categories were considered for inclusion in the questionnaire based on a review of studies recognizing them as important factors to support the effective implementation of SSI-based instruction. Below we provide a literature review of each category.

2.1 Core Aspects of SSI-Based Instruction
The SSI-based instruction framework developed by Presley et al. (2013) identifies design elements, learner experiences, and teacher attributes as core aspects for teaching and learning science in the context of SSI. Features of the design element of SSI-based instruction emphasize the importance of building instruction around a compelling issue, providing scaffolding for higher-order thinking practices (e.g., argumentation, reasoning, and decision making), and designing a culminating learning experience. For the aspect of required learner experiences, some SSI studies suggest activities, such as the need to engage students in constructing scientific argumentation practice (Venville & Dawson, 2010; Jiménez-Aleixandre & Erduran, 2008) and activities of collecting and analyzing scientific data related to an SSI (Sadler, 2011). These activities not only achieve the SSI educational goals, but also reflect the main competencies of the national science curriculum in Indonesia (Ministry of Education and Culture [MOEC], 2016).
Further, for teacher attributes, the SSIs education framework also identifies the necessity for teachers to understand the science content underlying the issue and have awareness of the social dimensions of the issue (Ratcliffe & Grace, 2003; Presley et al., 2013). High awareness of these core aspects can help support teachers to effectively design and implement SSIs teaching and learning activities.

2.2 Challenges of SSIs-Based Instruction Implementation

Previous studies of SSIs teaching have revealed a range of challenges that may hinder teachers from implementing SSIs teaching. For example, Lee and Yang (2019) found that when addressing SSIs in the science class for the first time, teachers encountered some challenges in transforming their traditional role of teaching science content as specified in the curriculum and actively engaging students in SSIs discussion activities. In addition, some studies have also acknowledged the importance of the availability and accessibility of SSIs teaching resources for teachers when they are implementing SSIs teaching. For instance, an SSIs pedagogical model with a clear instructional sequence is useful to guide teachers in SSIs teaching implementation (Saunders & Rennie, 2013). In addition, science textbooks that include perspectives from social science disciplines on various topics may help teachers to identify relevant social issues for their SSIs teaching (Morris, 2014).

A study by Borgerding and Dagistan (2018) revealed several pre-service science teachers’ concerns when teaching SSIs, such as lacking sufficient knowledge to appropriately identify an SSIs from other controversial science issues and knowing how to integrate science content into SSIs instruction. The need to adhere closely in scope and sequence to a curriculum with many learning objectives can also be a barrier for a teacher attempting to implement the full features of SSIs teaching. In this case, lack of time and room to maneuver in the curriculum may limit teachers to only being able to use SSIs as a motivational instrument for students to learn biology content or to frame their teaching activities using an SSIs-based approach (Tidemand & Nielsen, 2017).

In the context of Indonesian science education, exploration of all these SSIs teaching challenges is also relevant since the educational system has a national curriculum policy determined by the Ministry of Education and Culture (MOEC) that sets the goals and competencies of science education, the standards of science teaching and learning, the scope sequence for implementing the curriculum, and the process and procedures for developing science textbooks (Faisal & Martin, 2019).
2.3 Pedagogical Knowledge Needed to Implement SSI-based Instruction

Pedagogical knowledge is one of the elements of the pedagogical content knowledge (PCK) construct. A simple definition of PCK is that it represents the combination of teachers’ understanding of particular subject matter and pedagogical strategies that allow them to assist students to learn particular content knowledge in a meaningful way (Fraser, 2016). For instance, teachers use illustrative and well-labeled diagrams to help students visualize and internalize some abstract concepts of genetics (Mthethwa-Kunene et al., 2015). In the domain of science education, Magnusson et al. (1999) proposed five components of PCK: (1) orientations towards teaching science, (2) knowledge of science curriculums, (3) knowledge of instructional strategies, (4) knowledge of student understanding of science, and (5) knowledge of student assessment. In this study, we focus more on the pedagogical knowledge related to SSI-based instruction.

Although SSI-based instruction shares common features with other pedagogical approaches, some existing SSI instructional models indicate that teachers need to have specific pedagogical knowledge that allows them to design a learning environment that represents the features of an SSI classroom (Saunders & Rennie, 2013; Presley et al., 2013; Sadler et al., 2017). In addition, having an understanding of the science content related to the SSI is also one of the prerequisites for teachers to effectively facilitate SSI discussions (Zeidler et al., 2011). As the teaching and learning process that teachers in Indonesian schools should follow is governed by the curriculum standards developed by the government (MOEC, 2016), teachers also need to understand how to align the competencies in the national curriculum and the element of SSI-based instruction.

2.4 Attitudes and Beliefs about SSI-based Instruction

Since there have been few studies directly measuring teachers’ attitudes and beliefs about SSI-based instruction, we considered studies related to pre-service and in-service science teachers’ attitudes and beliefs about science teaching. “Attitude” is defined as the feelings that a person has about an object, based on their knowledge and belief about that object (Kind et al., 2007). The object in this study refers to SSI-based instruction. In the context of teaching and learning science, learning experiences gained from participating in science methods courses potentially change pre-service teachers’ attitudes about science teaching (Kazempour & Sadler, 2015).

In addition, a study conducted by Erden and Sönmez (2011) indicated that attitudes towards science teaching significantly affect the frequency of science
activities that teachers provide in their classroom, which is important, as activities are essential for SSI teaching (Friedrichsen et al., 2016). Further, the word “beliefs” is used to characterize a teacher’s own particular system of thought about objects, people, and events and their characteristic relationships that affect their planning and interactive thoughts and decisions (Mansour, 2008). Beliefs are an important factor that affect teachers’ teaching practice in terms of how they teach science and why they teach science in certain ways (Fitzgerald et al., 2013). In SSI teaching, teachers’ beliefs affect how they decide to implement an SSI pedagogical strategy (Tidemand & Nielsen, 2017).

Another study focused on graduate student teaching assistants found that beliefs affected the way the teaching assistants framed their instructional approach around controversial issues used in SSI lessons (Gardner & Jones, 2011). In addition, teachers’ beliefs about teaching and learning positively relate to their participation in continuing professional development programs (De Vries et al., 2014). Moreover, a well-designed and well-implemented professional development program can potentially positively affect teachers’ beliefs about teaching science, and such beliefs may play an important role in the quality of their teaching and ultimately student learning (Lumpe et al., 2012).

However, not all teachers’ beliefs turn into practices. The mismatch between teachers’ expressed beliefs and their observed practices may hinder putting their beliefs into practice (Mansour, 2008). For instructors new to SSI teaching, factors such as control and autonomy, time and knowledge limitations, personal biases, and concern for their role in promoting social activism in the classroom can be a constraint and cause disconnection between their perspectives and practices (Gardner & Jones, 2011).

3 Research Methods

3.1 Participants
At the beginning of the semester, the 52 biology teachers who enrolled in this course and were divided into two classes (Classes A and B). All teacher participants consented to participate in post-surveys and interviews at the end of all course sections. The criteria for involving teachers in the data collection and analysis were that they need to have completed all the course sessions (including all classroom sessions and all SSI practice teaching sessions). Forty-five teachers (31 pre-service; 14 in-service biology teachers) both consented to participate in the data collection process and met the criteria of having completed all sessions. Thus, in this study, we report on findings of 45 of the 52 participants. The in-service biology teachers taught in public and private...
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secondary schools and had various amounts of teaching experience, ranging from 1 to 15 years.

3.2 Context
The science methods course in this study was a compulsory subject (3 credits) that is taught in the first semester of the biology education program at a TEI in Indonesia. The original course syllabus addressed various teaching and learning strategies and assessment methods for secondary school science. However, to meet the purpose of this study, the first half of the semester was specifically designed to introduce pre-service and in-service teachers to content related to scientific literacy, SSI's, and scientific argumentation. The course content was created by reviewing relevant literature and emphasizing research-based knowledge about these core topics. The course consisted of two sections: classroom lecture sessions and SSI practice teaching sessions. The content and activities of each section are described below.

3.2.1 Classroom Lecture Sessions
The classroom lecture sessions were carried out over 4 weeks, taught as a single 2.5-hour session every week. The classroom environment was designed to engage teachers in collective activities throughout the course. At the start of the course, teachers were organized into five heterogeneous groups of 4–5 people and consideration was given to mix teachers into groups based on gender and teaching experiences. These arrangements were aimed at increasing interaction and discourse between teachers to support their learning processes. In addition to the classroom activities, teachers were provided assignments between each lecture session to support them to further explore the content of the coursework.

At the beginning of the lecture course, teachers were presented with the framework of scientific literacy for the 21st century. The definitions and frameworks draw from the structure of the Indonesian national curriculum competencies (MOEC, 2016), PISA framework for scientific literacy (OECD, 2018), and from international literature studies on science education (Choi et al., 2011; Osborne, 2014). Teachers also discussed the importance of scientific literacy and how to promote its implementation in science teaching practice in school. Teachers were encouraged to share ideas about the challenges of scientific literacy in Indonesian science education and what possible alternatives to support students’ achievement of the national curriculum’s science competencies.

In the second lecture session, teachers discussed the situated learning perspective as a theoretical framework to introduce a new teaching and learning approach in the science classroom (Sadler, 2009). The discussion centered
around the definition of SSIs as social issues that are conceptually related to science (Sadler & Zeidler 2005; Zeidler, 2014); the controversial nature of SSIs, which are connections between science and society (Oulton et al., 2004; Levinson, 2006); some examples of SSIs that have been investigated in the science education research; and the positive effects of studying SSIs on the students’ learning (Sadler, 2009). Then, referring to the SSIs definition, teachers selected one topic that they considered an SS and tried to identify the related science content and social, economic, or environmental implications of the issue. Teachers were also required to explain the selected issues from the personal, societal, and global perspective. Each group of teachers prepared a 10-minute presentation for this assignment.

In the third lecture session, teachers discussed the framework of SSIs-based instruction. Teachers identified common features of SSIs-based instruction from the existing SSIs pedagogical model (Ratcliffe & Grace, 2003; Sadler et al., 2017) and some teaching and learning strategies for SSIs classrooms (Lee et al., 2013; Saunders & Rennie, 2013). Teachers were then challenged to connect the theoretical explanation of the SSIs framework to their biology teaching and learning experience. The assignment for the third session consisted of teachers reviewing an example of an SSIs learning scenario. The SSIs learning scenario was adapted from a study by Chung et al. (2016). A learning scenario includes a sequence of SSIs lesson (7 classes) and excerpts and examples documenting students’ experiences during these lessons. Teachers were asked to give comments or questions about individual components of the lessons, the design of the teaching and learning activities, and responses to students’ experiences described in the learning scenario.

In the lecture fourth session, teachers were introduced to the definition of argument and to Toulmin’s argumentation pattern (Sadler, 2006). Teachers explored the teaching of argumentation using appropriate pedagogical strategies. These strategies included posing open-ended questions, constructing a case for argumentation, encouraging the use of data as evidence, encouraging listening and prompting justification, and using writing frames (Simon et al., 2006; Yilmaz et al., 2017). In their groups, teachers also discussed some examples of these scientific argumentation teaching strategies and shared their ideas in the whole-class discussion about how they have used them or could use them in real classroom contexts.

3.2.2 SSIs Practice Teaching Sessions
After participating in the classroom lecture sessions, teachers engaged in SSIs teaching practice sessions. The SSIs teaching practice employed three phases: (1) planning, (2) lesson implementation, and (3) post-teaching reflection. Teachers each class were organized into groups of three, comprising seven
to eight teachers per group. Each group of the three groups prepared an SSI lesson plan and supporting teaching materials (presentations, instructional media, and reading material) for the different grades of the secondary school level (10–12). Each week, one of the three groups in each class implemented their lesson to members of the other groups (see Table 1).

During the lesson implementation phase, one member of each group took the role of a teacher to implement their SSI lesson plan and the remaining teachers acted as secondary school students. Soon after the lesson implementation phase, teachers conducted a post-teaching reflection activity in which the teachers exchanged views and provided feedback to one another about their experiences while engaging as teachers and learners in the lesson planning and implementation phases.

### 3.3 Data Collection

The data collection processes were implemented sequentially during the study (Figure 1). The data collection process employed a mixed-methods design, which combined quantitative and qualitative methods (Greene, 2008). To collect the quantitative data, we developed socio-scientific issues (SSI)-based instruction (BI) questionnaire. Teachers completed the SSI-BI questionnaire after engaging in the course. To collect the qualitative data, teachers were asked

| Session | Biology topic/School grade | SSI topic | Teaching method |
|---------|-----------------------------|-----------|-----------------|
| 1 (Class A) | Air pollution/Grade 10 | Chlorofluorocarbons (CFCs) and global warming | Small-group and whole-class discussions |
| 2 (Class A) | Human digestive system/Grade 11 | Vegetarian diet | Cooperative jigsaw method |
| 3 (Class A) | Biotechnology/Grade 12 | Cloning | The class debate method |
| 4 (Class B) | Virus/Grade 10 | HIV/AIDS | Expert panel discussion |
| 5 (Class B) | Human reproduction system/Grade 11 | In vitro fertilization (IVF) | Small-group and whole-class discussions |
| 6 (Class B) | Mutations/Grade 12 | Antibiotic resistance | The class debate method |
to complete course assignments each week and participate in semi-structured interviews at the end of the course. These methods enabled triangulation of the data from different sources, which can help improve data validation (Johnson & Christensen, 2013).

3.3.1 The Socio-Scientific Issues (SSI)-Based Instruction (BI) Questionnaire

The development of the socio-scientific issues (SSI)-based instruction (BI) questionnaire was carried out in three steps: (1) identifying questionnaire scales and developing the items, (2) initial review and revision, and (3) testing the validity and reliability of the questionnaire scales. To create the items of the questionnaire scales, we examined some existing questionnaires that measured perceptions both of science teaching and SSIs (Lee et al., 2006; Kara, 2012). In some cases, we developed new items to complete the scale construct. The content of the new items was based on major findings from previous studies related to perceptions and practices on SSI-based instruction (see Gardner & Jones, 2011; Ekborg et al., 2013; Tidemand & Nielsen, 2017; Zangori et al., 2018). The SSI-BI questionnaire used a four-point Likert scale, which was successfully adapted to measure teachers’ attitudes towards science teaching (Erden & Sönmez, 2011). The positions on each scale were strongly disagree (1), disagree (2), agree (3), and strongly agree (4).

After completing the initial draft of 25 items, two proficient researchers of SSIs and science education verified the content validity of the questionnaire. Following this step, the questionnaire was translated into Bahasa Indonesia. The language conformity was reviewed by an English-Indonesian professional translator. We invited two biology teacher educators in Indonesia to review the clarity and readability of the questionnaire to verify the face validity of the items. This review process mainly provided feedback about the general content and wording of the questionnaire to ensure the questionnaire was clear and readable for the teacher respondents.
The SSIS-BI questionnaire was then piloted to measure its validity and reliability. In the pilot study, we collected 123 responses from biology teachers and performed an exploratory factor analysis to identify the factors that clustered together. From the analysis, Bartlett’s test of sphericity was significant (BTS value = 1.698, \( p = 0.000 \)), and the initial measurement of the KMO value of adequacy was also found to be significant (0.861). This result suggested the appropriateness of the data to run the factor analysis. Following this test, the 25 items of the SSIS-BI questionnaire were then factor analyzed with varimax rotation (Pallant, 2010), resulting in four factors with initial eigenvalues greater than 1.0. The items were then selected when the factor loading was greater than 0.5. Based on the factor analysis, two items failed to have substantially high factor loading on any factor and two items did not load in the same factor. These items were deleted, and the factor analysis was recomputed with the remaining 21 items (see Table 2).

The second factor analysis produced four factors where the total percentage of variance extracted was 68.75% over the 21 items. This result supported the assumption that the 21 items that formed the four factors (1) core aspects of SSIS-based instruction, (2) challenges in implementation, (3) pedagogical knowledge needed for implementation, and (4) attitudes and beliefs about SSIS-based instruction of the SSIS-BI questionnaire were conceptually valid in their relationship to the theoretical framework (see review of literature above). The analysis was then continued by testing the item reliability using Cronbach’s alpha coefficient. Analysis of item reliability found Cronbach’s alpha coefficient for each of the four factors greater than 0.7 (see Table 2). This value indicates an acceptable level of internal consistency reliability (Johnson & Christensen, 2013).

3.3.2 Semi-Structured Interviews and Course Assignment

Twelve teachers were also selected for the interviews at the end of the course. The interview process was set up in a one-on-one format. The interview questions were designed to complement the questionnaire’s data and to gain detailed explanations about the teachers’ perceptions of and attitudes about SSIS-based instruction. All interviews were audio-recorded and transcribed verbatim. In addition, teachers were asked to complete a course assignment. The assignment was to review an SS1 learning scenario (see the third lecture session above).

3.4 Data Analysis

3.4.1 Quantitative Analysis

Data from the SSIS-BI questionnaire were analyzed to describe teachers’ perceptions and attitudes of SSIS-based instruction. The frequency of the teachers’
responses and the mean score of each SS1S-B1 questionnaire item was calculated using SPSS software.

3.4.2 Qualitative Analysis
The interview data analysis followed the two main stages of the coding process explained by Miles, Huberman, and Saldaña (2013). In the first stage, 12 of the interview recordings were prepared and transcribed verbatim. The interview transcripts were refined to correct mispronunciations and incomplete sentences. Then, to enhance the data credibility, the interview transcripts were sent back to the teachers to confirm the accuracy of the transcripts. Before the
coding process, the transcripts were read several times to understand the contents of the interviews. Following this step, the first author assigned codes to the interview transcripts using manual coding to yield a series of codes about teachers’ views of the SSI s-based instruction and its implementation. The list of the emerging codes from the first stage was re-read to ensure consistent coding across the 12 interview transcripts and revised when necessary.

Then, another science education researcher re-examined the interview transcripts using the emerging code list. We resolved the discrepancies of the coding process through iterative discussions which were used to negotiate and develop several agreed upon categories. The categories that emerged were then used as a coding frame to examine the text generated in the course assignments. In the final step, the relevant categories were interpreted and described in alignment with the four scales of the SS1s-B1 questionnaire.

4 Results

The results are presented in a manner that incorporates quantitative and qualitative data trends. The data from the questionnaire is presented first and followed by the results from the interviews (I) and course assignments (CA).

4.1 Perceptions of the Core Aspects of SS1s-Based Instruction

The scale of the core aspects of the SS1s-B1 questionnaire includes six items that were developed to assess teachers’ perceptions of design elements (Items 1 and 2), learning experience (Items 3 and 4), and teacher attributes (Items 5 and 6) of the SS1s-based instruction. Examining teachers’ responses to the individual items suggested that most teachers tended to strongly agree with the necessity to employ appropriate teaching strategies (M1 = 3.58), facilitate students to access various learning resources (M2 = 3.64), the importance of understanding the science content (M5 = 3.80) and the social implications of the ss1 (M6 = 3.64) in ss1s-based instruction (see Table 3).

The questionnaire results suggest that teachers had a high awareness of some ss1s teaching aspects after participating in the course. As the teachers in this course reported they had not received any education about ss1s before the course and were not aware of ss1s as an instructional strategy, pre-course responses is not useful to report in this study. Instead, we focus on reporting teachers’ post-course questionnaire responses. The interview and course assignment analyses provided a deeper understanding of the teachers’ perceptions about core aspects of ss1s-based instruction. Teachers identified the main features of ss1s-based instruction that they thought were different...
First, teachers explained the role of an SSI as a starting point for students to learn the science concepts and they discussed the criteria for selecting the SSI topic. Teachers acknowledged that SSI could provide relevant contexts for science learning, and therefore, they noted that selecting SSI topics that align with the biology curriculum and students’ experiences is important for effective implementation. The following interview excerpts and comments in the course assignments reflect teachers’ ideas about this.

The SSI presented in the classroom should connect to the biology topic and be based on students’ experiences. Students will be enthusiastic in learning biology and gaining information about that issue.

Interview participant 2

What I understand about SSI-based instruction is that teachers introduce the issue at the beginning of the lesson. In the instructional objectives, teachers also describe the interrelationship between the selected SSI and biology learning topic.

Interview participant 7
The genetic engineering issue [the example of an SSI used in the course assignment] is applicable for the biology curriculum in Grade 9, particularly for the biotechnology topic.

Course Assignment response, Teacher 1

A specific SSI will raise students’ curiosity and interest if the issue is directly related to their daily life and society.

Course Assignment response, Teacher 3

Second, the teachers generally recognized debate and role play as a culminating activity for the SSI classroom. They explained that setting up the classroom activities in a debate or role play allows students to see the issue from a different perspective from their peers. The teachers’ perceptions of this aspect can be seen in the following interview excerpts and comments in the course assignments.

For the issue involving multiple parties, role play seems to be the right choice, even though only one or two students often dominated the discussion in this classroom setting.

Interview participant 3

The teacher can use methods such as group discussion, debate, posing a critical question about the risks and benefits of the issue, or asking students to create a poster showing the positive or negative impact of the issue.

Interview participant 8

Teaching SSIs using the cooperative jigsaw strategy and role-play method will allow students to search for information about the issue, share their opinions, and improve their communication skills.

Course Assignment response, Teacher 16

The role-play method is most suitable for SSI teaching because each student has a different role ... so they can discuss the issue from many aspects.

Course Assignment response, Teacher 18

Third, teachers recognized the necessity to prepare or identify various learning resources, such as video, presentation, articles, and websites, for SSI-based
instruction. The following interview excerpts and comments from the course assignments indicate teachers’ concerns about the importance of employing various learning resources for SSI teaching.

The information about the SSI may not be explained in the textbook. I prefer to find information about the issue from official websites. For instance, if students need information about the number of cases of a particular disease, I will recommend accessing the Ministry of Health website. By using an official website, students will get valid information related to the issue.

Interview participant 4

In my experience, in some schools, students have no internet access or the school may not have sufficient teaching facilities. It will be helpful if the teacher can create a student worksheet that includes information or data about the SSI from different sources.

Interview participant 10

Introducing the science concepts of an SSI using a video is helpful, particularly for junior secondary school students.... They need real examples to understand the issue.

Course Assignment response, Teacher 5

Teacher comments reflect not only concerns about how to source reliable information, but also about access to the resources needed to support instruction. In Indonesia, students and teachers working in remote mountains and small islands, as well as teachers in large urban centers, may lack access to material resources needed for SSI (Faisal & Martin, 2019). In terms of student learning experiences, teachers identified most of the teaching and learning activities that were needed to promote SSI argumentation. For example, teachers explained that students could engage in argumentation by exploring multiple views about the SSI and then presenting their own views on such issues. The following interview excerpts show teachers’ views about the SSI learning experience.

In the SSI classroom, students not only learn about the biological concepts from the textbook or teacher presentations, but also, they can use the concepts to support their positions on the issue.

Interview participant 4
After presenting the societal issue to the students, we also need to explain various perspectives about the issue and then facilitate students’ development of their arguments with theory and data.

Interview participant 7

Students are expected to develop their arguments or counter-arguments using data from different sources. It depends on the teacher. They can provide the data in the student worksheets or ask students to search for the data on the internet.

Interview participant 9

The last core aspect is teacher attributes. Teachers identified several attributes and roles to effectively implement SSI-based instruction, such as understanding the science content related to the SSI and positioning themselves as the students’ learning facilitator. In the interviews and course assignments, teachers explained:

The most important thing is understanding the biology content and its connection to the issue being discussed. It will be problematic if the biology content and the issue are far from what is required in the curriculum.

Interview participant 4

In the professional development program, I was often informed that the teacher is a facilitator for students’ learning, and I think this role is very important for SSI teaching, where teachers select a relevant issue and provide learning resources.

Interview participant 3

Before presenting the genetic engineering issue’s moral aspect, teachers need to explain the principles of genetic engineering technology.

Course Assignment response, Teacher 15

In my opinion, the teacher does not need to determine students’ roles regarding the SSI. The teacher just provides different roles and guiding questions for the discussion. Let students select their own roles. In this way, the discussion will occur naturally.

Course Assignment response, Teacher 24

Overall, teachers’ response show a high awareness of some SSI teaching aspects, and they identified the features of SSI teaching in terms of design
elements, learning experience, and teacher attributes. The following subsection describes teachers’ perceptions of the challenges of the SSI-based instruction implementation.

4.2 Perceptions of the Challenges in SSI-based Instruction

This scale addresses various challenges that teachers may face when designing and implementing SSI-based instruction. The item content of this scale is presented in negative statements. Six types of SSI teaching challenges from the previous research were included in this scale. The first challenge was transforming teachers’ teaching styles to implement SSI-based instruction (Item 7). This challenge is also related to how teachers organize students’ learning activities in the SSI classroom (Item 9). Other challenges were the lack of SSI teaching materials (Item 8) and ideas for aligning components of SSI-based instruction with the biology competency of the national curriculum (Item 10). The two last challenges in this scale were the challenges in identifying appropriate societal issues (Item 11) and connecting these issues with biology content (Item 12).

Examining the mean values of the individual items revealed some interesting findings. Teachers seemed to better recognize factors such as accessing SSI teaching materials ($M_7 = 3.22$), identifying relevant social issues ($M_{11} = 3.18$), and connecting biology content and SSI ($M_{12} = 3.16$) as challenges that may hinder biology teachers from implementing SSI-based instruction (Table 4).

| Item |  
|------|---|---|---|---|---|---|---|
|      | Std | D  | A  | sa | M  | sd |
| 7. I think it will be difficult for a biology teacher to transform their teaching style in order to implement SSI-based instruction. | 0  | 7  | 35 | 3  | 2.91 | 0.46 |
| 8. I think it will be difficult for a biology teacher to access relevant teaching materials to implement SSI-based instruction. | 0  | 5  | 25 | 15 | 3.22 | 0.63 |
| 9. I think it will be difficult for a biology teacher to organize students’ learning activities to implement SSI-based instruction. | 1  | 8  | 29 | 7  | 2.93 | 0.65 |
| 10. I think it will be difficult for a biology teacher to align components of SSI-based instruction with the national biology curriculum standards. | 1  | 8  | 28 | 8  | 2.96 | 0.67 |
In general, the questionnaire results show that most teachers recognized the challenges of the SSI teaching implementation for biology teachers in school. In the interview, teachers identified various challenges of SSI teaching. The three major categories of challenges were the curriculum requirements, teacher competency, and student characteristics.

Most teachers acknowledged that in a particular case, curriculum structure (content and competencies) could be an obstacle to implementing SSI teaching. The following interview excerpts show teachers' views about this challenge.

I think one of the challenges for teachers is selecting an appropriate learning topic in the school biology curriculum. Not all biology topics can be taught with this approach [SSI teaching]. For example, our group selected the in vitro fertilization issue, and we found it difficult to connect this issue with the biology topic and competency in the curriculum. We also found limited information about this issue provided in the textbook.

Interview participant 5

The biology content and competency in the curriculum needs to be completed within a certain period, which can be a challenge for teachers when they want to implement SSI teaching. They need to manage their SSI learning scenario..., so all the learning topics in the curriculum can be delivered by the end of the semester.

Interview participant 12

The second category is challenges related to teacher competency. The teachers interviewed explained that the implementation of SSI-based instruction in schools may present challenges for teachers. They recognized that teachers

| Item                                                                 | Std | D  | A  | SA | M    | sd  |
|---------------------------------------------------------------------|-----|----|----|----|------|-----|
| 11. I think it will be difficult for a biology teacher to identify appropriate social issues to implement SSI-based instruction. | 0   | 4  | 29 | 12 | 3.18 | 0.57 |
| 12. I think it will be difficult for a biology teacher to appropriately connect biology content and SSI issues in the same lesson. | 0   | 4  | 30 | 11 | 3.16 | 0.56 |

StD = strongly disagree; D = disagree; A = agree; SA = strongly agree; M = Mean; SD = standard deviation
are not familiar with the student-centered approaches for SSI teaching, such as managing debate activities and engaging students in SSI-related discussions. The following interview excerpts provide teachers’ views about these challenges.

The biggest challenge is presenting the controversial aspect of the issue, particularly when teachers want to use the debate method. The pros and cons groups of students need to understand their positions on the issue.

Interview participant 2

For implementation in the school, I think the challenge for teachers are providing guiding questions for the students to discuss the SSI.... If teachers do not provide specific questions, students’ discussions about the issue may be far from what they [the teachers] expected.

Interview participant 3

I think there are many important issues around us, but it is difficult to discuss them in class. Not all teachers are aware of the social implications of the issue.

Interview participant 10

The third category is challenges related to the student characteristics. In the interviews, several teachers stated that high school students might lack the motivation to find and read more information about the SSI. The following interview excerpts are examples of teachers’ views about these challenges.

I have been teaching for almost 10 years, and I think it is difficult for junior secondary school students to discuss SSI.... Maybe the most challenging thing is to encourage them to read the science content about the issue.

Interview participant 3

It is important to encourage students to express their opinions. In my experience, many students lack the capacity to argue or express their opinion in the classroom discussion. Only a few vocal students want to speak and share their ideas.

Interview participant 9

If teachers want to use SSI in their biology classroom ... I think they first need to ensure that their students have high learning motivation and academic competency.

Interview participant 11
The category of SSI's teaching challenges that teachers identified in this study may share similar types with the challenges reported in the previous research. However, the specific challenges that teachers acknowledged such as national curriculum structure, teachers' familiarity with the methods for teaching SSI's, and students' motivation provide important information for researchers and science teacher educators to support teachers in designing and implementing SSI's-based instruction, particularly for the school science teaching in Indonesia. In the following sub-section, we describe teachers' perceptions of their knowledge concerning some of the pedagogical aspects of SSI's-based instruction.

4.3 Perceptions of the Pedagogical Knowledge Needed for SSI's-Based Instruction

The third scale of the questionnaire consists of four items designed to explore the pedagogical knowledge necessary to implement SSI's-based instruction. The first item asks about perceptions about knowledge in terms of formulating SSI-related instructional objectives that can promote scientific literacy (Item 13). In line with the first item, an item asking about perceptions of knowledge of kinds of activities students need to engage in when learning biology using SSI's was also included in this scale (Item 16). The content of Items 13 and 16 is closely related because different SSI's teaching strategies or methods are more suitable to facilitate the achievement of particular learning outcomes. Another item of this scale asks about the perception of the knowledge needed to align standards of the national biology curriculum with elements of SSI's-based instruction (Item 15). This scale also includes an item asking about perceptions about the biology content knowledge necessary for implementing SSI's-based instruction (Item 14).

Examining the mean values of the individual items indicate that teachers perceived themselves as having sufficient knowledge to create instructional objectives representing scientific literacy competency ($M_{13} = 3.22$), understand the biology content necessary for teaching an SSI ($M_{14} = 3.24$), align an SSI with the components of the biology curriculum ($M_{15} = 3.11$), and create instructional activities ($M_{16} = 3.27$; Table 5).

Although the questionnaire results show that teachers felt confident about their understanding of SSI's pedagogical aspects, however, in the course assignments some teachers questioned the strategies useful for effectively managing the SSI discussion activities:

How can students be supported in the role-play activities so they can reach a consensus about the issue being discussed?

Course Assignment response, Teacher 6
What are the differences of the questions designed to attract students’ attention to the personal, social, and global aspects of the genetic engineering issue?

Course Assignment response, Teacher 19

In the interview, some teachers also expressed their concerns about how to actively engage students in SSI classroom:

Because this is a new approach [SSI teaching], it is not easy to implement it ... The most challenging thing for me is how to end the SSI discussion.

Interview participant 12

I am not sure that I can set up classroom situations to actively engage students. My big concern is how to manage the various classroom activities involved in SSI teaching and ask the kinds of questions that can stimulate students to think critically about an SSI.

Interview participant 4

TABLE 5  Teachers’ perceptions of the pedagogical knowledge they need to implement SSI-based instruction

| Item                                                                 | SD | D | A | SA | M     | SD |
|----------------------------------------------------------------------|----|---|---|----|-------|----|
| 13. I understand how to formulate SSI-based biology instructional objectives that can promote students’ scientific literacy. |    |   | 35| 10 | 3.22  | 0.42|
| 14. I understand the biology content knowledge necessary for implementing SSI-based instruction (e.g., biology facts, concepts, and principles). |    | 1 | 32| 12 | 3.24  | 0.48|
| 15. I understand how to align components of the national biology curriculum standards with SSI-based instruction. |    | 3 | 34| 8  | 3.11  | 0.48|
| 16. I understand what kinds of activities students need to be engaged in when learning using SSI-based biology instruction. |    |   | 33| 12 | 3.27  | 0.44|

StD = strongly disagree; D = disagree; A = agree; SA = strongly agree; M = Mean; SD = standard deviation
Designing SSI lessons requires extra effort ... [including] selecting the issue and preparing a lesson plan and teaching materials, and I think I still lack the capacity to do these tasks.

Interview participant 5

The specific concerns that teachers expressed in the course assignment and interviews are not covered in the questionnaire items. Therefore, presenting these data allows us to further explore teachers’ perceptions of their pedagogical knowledge needed for SSI-based instruction. The qualitative findings from the course assignments and interviews suggest that the controversial nature of SSI and the need to actively engage students in critical thinking activities seem the most challenging aspects. Teachers may need a longer engagement in the professional development program discussing SSI and more opportunities to practice SSI teaching in order to develop their confidence for addressing SSI in their future classrooms.

4.4 Attitudes and Beliefs about SSI-Based Instruction

This fourth scale of the questionnaire is specifically designed to measure attitudes and beliefs regarding SSI teaching. The attitude aspect of this scale covers interest in introducing SSI-based instruction in the future biology classroom (Item 17), willingness to collaborate with other biology teachers to develop SSI-based teaching materials (Item 18), and willingness to participate in professional development programs supporting teachers to implement SSI-based instruction (Item 19). The beliefs aspect in this scale emphasizes beliefs about the significance of the SSI-based instruction to support students to achieve the biology competencies in the national curriculum (Item 20) and beliefs about SSI-based instruction as an appropriate teaching strategy to promote students’ scientific literacy (Item 21). Examining the mean values of the individual items indicates that all items have a positive trend (Table 6).

The questionnaire results above show that teachers had positive attitudes about introducing SSI into their biology classrooms (M17 = 3.67), working collaboratively in their professional learning communities to develop SSI teaching materials (M18 = 3.58), and participating in professional development programs to learn about SSI (M19 = 3.49). Consistent with the questionnaire results, in the interviews, teachers also showed high interest in developing and implementing SSI teaching. The following interview excerpts show teachers’ attitudes about SSI-based instruction.
I think [the use of] SSI is a new approach to teaching science.... It is also interesting to introduce it to the students. Honestly, I just know this teaching approach from our course.

Interview participant 3

When we discussed this pedagogical approach [SSI] in the class, I realized that there is a teaching method like this..., using real problems in society. Even though I have just learned about this method, I think it will be interesting to implement it.

Interview participant 5

I am interested in SSI teaching.... As we know, the government now encourages teachers to employ a student-centered approach.

Interview participant 6

I want to use SSI in my class.... I think SSI will help students become more enthusiastic about learning science.

Interview participant 10
The comments above indicate the positive attitudes of teachers about SSI-based instruction. It seems that SSI is a new and interesting pedagogical approach for teachers, and they see that introducing such teaching into the biology classroom would be beneficial for students’ learning.

The questionnaire results also show that teachers had strong beliefs about the potency of SSI-based instruction to help students meet the national biology curriculum standards (M20 = 3.47) and promote scientific literacy (M21 = 3.56). In the interviews, teachers identified some SSI learning outcomes related to the scientific literacy that students can achieve and recognized that SSI teaching is relevant to the national curriculum goals. The following interview excerpts indicate teachers’ beliefs about SSI-based instruction.

I think SSI teaching includes some aspects of scientific literacy. The most related aspect is when students discuss and share their perspectives about an issue. Students can understand science more easily when they connect it with problems around them or with the news they hear from mass media.

Interview participant 2

As I know, one purpose of the science curriculum is to ask teachers to apply the scientific concepts to daily life problems. I think using SSI is appropriate to achieving this purpose.

Interview participant 3

Because this teaching method [SSI teaching] requires students to explore the social aspects of the issue, it might be [a] positive [influence on] developing their confidence in arguing about the issue and practicing critical thinking skills.

Interview participant 9

Teachers believed that through SSI teaching, students can develop critical perspectives about information from the mass media, allowing students to connect what they learn in class with the problems that they might encounter in their daily life, and improve students’ confidence in discussing societal issues.

5 Discussion

In this section, we discuss some important findings regarding the four scales of the SSI-BI questionnaire and we also share findings from teachers’ interview responses and their course assignments to support our claims.
5.1 Understandings About Core Aspects of SSI-based Instruction
The first scale is the core aspects of SSI-based instruction. The questionnaire analysis suggests that teachers had a high awareness of some SSI teaching aspects. Teachers’ awareness was also reflected in the interview and their comments in the course assignments. Teachers acknowledged that SSI could provide relevant contexts for science learning and the importance of selecting SSI topics that align with the biology curriculum and students’ experience. Introducing an SSI in the classroom that is personally or socially relevant to students is useful in contextualizing science topics (Zeidler & Nichols, 2009). In addition, the science teaching and learning practices in Indonesian schools need to follow standards and competency determined by MOEC (Faisal & Martin, 2019).

Consistent with SSI literature, teachers in this study suggested debate and role-play methods for the SSI classroom. Teachers explained that these methods allow students to discuss the issue from a different perspective. One feature of the SSI classroom is students’ engagement in the SSI discourse (Zeidler et al., 2011). To encourage students to participate in this activity, debates have been widely recognized as an effective strategy (Molinatti et al., 2010).

Teachers also pay particular attention to the necessity of preparing various learning resources and positioning themselves as the students’ learning facilitators to support the implementation of SSI-based instruction. Since the SSI discourse involves multiple perspectives that include social, ethical, and political dimensions, it is essential to support students’ learning activity by providing various sources of information such as the internet, newspapers, and scientific articles (Ratcliffe & Grace, 2003). Other important teaching materials are SSI lesson plans with clear sequences of teaching and learning activities (Saunders & Rennie, 2013) and SSI worksheets that include guiding questions for the context of students’ discussion (Chung et al., 2016) and case descriptions to facilitate students’ problem-solving activities (Zangori et al., 2018). Without SSI teaching materials, teachers will focus on teaching factual and conceptual aspects of science (Day & Bryce, 2011).

5.2 Recognizing the Challenges in SSI-based Instruction
The second scale is the challenges in SSI-based instruction. The questionnaire analysis and data from the interviews and course assignments show that most teachers recognized the challenges of the SSI teaching implementation for biology teachers in school. Teachers acknowledged that there is a great deal of biology content and competency in the national curriculum, and the requirements for teachers to follow the national standards in designing their teaching
and learning activities could be an obstacle to implementing SSI teaching. The curriculum is a peripheral factor that significantly influences the core aspects and classroom environment of SSI-based instruction (Presley et al., 2013). The rigidity of the curriculum structure may hinder teachers’ inclusion of social and ethical dimensions of science in their classroom (Levinson, 2006).

The participating teachers also recognized that teachers in schools may not be familiar with the student-centered approaches for SSI teaching. Some features of SSI-based instruction such as the use of a complex and socially relevant issue as a central theme and engaging students in higher-order thinking practices (Presley et al., 2013; Saunders & Rennie, 2013) require teachers to adapt constructivist teaching approaches to be successful in the implementation.

In addition, teachers acknowledged that high school students might lack the motivation and biological content knowledge to discuss the science and social dimensions of the SSI. The controversial and open-ended nature of SSI often makes them difficult topics to be discussed in the regular science classroom (Levinson, 2006). Teachers in other studies have also been concerned that students may find it difficult to critically examine arguments about SSI (Ekborg et al., 2013) and to discuss controversial science topics (Borgerding & Dagistan, 2018).

5.3 Pedagogical Knowledge Needed for SSI-Based Instruction

The third scale is the pedagogical knowledge needed for SSI-based instruction. The questionnaire analysis shows that teachers perceived themselves as having sufficient knowledge of some SSI pedagogical aspects. Knowledge about science content related to the issue is necessary for teachers to present the science dimension of the issue and to contribute to the ideas and knowledge in SSI discussions (Zeidler et al., 2011). In addition, since the term “SSI” is not explicitly described in the science curriculum (MOEC, 2016), teachers need to carefully consider what SSI topics are well suited to the biology content and competencies in the national curriculum. Also, in the SSI-based instruction, selecting appropriate issues is important due to the issue of providing a context for students’ learning.

However, in the interviews and course assignments, teachers expressed concerns about their capacity to design SSI lessons. Teachers were particularly concerned about their capacity to effectively manage the SSI discussion activities. Previous studies have also revealed teachers’ concerns about handling discussions of value-laden issues in SSI classes (Sadler et al., 2006). This is due to the uncertainty of the SSI classroom discourses, where students may change the discussion directions to different social, ethical, or moral perspectives, thus
shifting teachers out of their mastery of knowledge both related to subject content and the SSI being discussed (Day & Bryce, 2011).

5.4 **Attitudes and Beliefs about SSI-based Instruction**

The fourth scale is attitudes and beliefs about SSI-based instruction. The questionnaire analysis indicates that teachers had positive attitudes and beliefs about SSI-based instruction. In the context of teaching and learning science, this result is consistent with the previous studies, which found that learning experiences gained from participating in science methods courses can potentially support teachers to develop positive attitudes about science teaching (Kazempour & Sadler, 2015). Teachers’ participation in the professional development programs also positively affects their attitudes (van Aalderen-Smeets et al., 2017) and beliefs (Lumpe et al., 2012) about science teaching.

In the interviews, teachers also showed high interest in developing and implementing SSI teaching for their biology classrooms. Teachers also believed that SSI teaching can help students achieve some competencies related to scientific literacy in the national curriculum. Teachers’ positive attitudes towards science teaching can influence their science classroom practice (Erden & Sönmez, 2011). In addition, in SSI teaching, teachers’ beliefs affect how they decide to implement an SSI pedagogical strategy (Tidemand & Nielsen, 2017). The aspect of beliefs is also likely to affect biology instructors in framing their instructional approach around controversial SSI issues (Gardner & Jones, 2011).

6 **Implications**

This study has several implications, particularly for science teacher education and professional development (PD), both internationally and in Indonesia. This study showed that pre- and in-service biology teachers held positive perceptions of their pedagogical knowledge and were aware of some core aspects of SSI-based instruction after participation in a short SSI teaching-oriented course. Therefore, researchers and science teacher educators in programs abroad and at TEIS in Indonesia are encouraged to consider the extent to which the components of the SSI teaching-oriented course in this study could be further developed and incorporated into other formal curriculums and when designing PD programs for science teachers.

This study also showed that teachers had positive attitudes and perceptions about SSI-based instruction. Given that some teachers in this study were members of local teacher communities, this finding is important for the
dissemination of the ideas of SSIs teaching to teacher professional communities in the Indonesian context. The use of this teaching approach in schools may support teachers to address the biology competencies outlined in the national curriculum. Pre- and in-service biology teachers in this study also identified curriculum demands as challenges for SSIs-based teaching implementation in local school contexts. This finding raises important questions for policy-makers about the goals of the national curriculum revision and for increasing the flexibility of the curriculum so that it can allow teachers to adopt new pedagogical approaches.

Additionally, teachers in this study recognized that biology teachers in schools may find it difficult to identify the controversial aspects of SSIs and to employ appropriate methods for SSIs teaching. This finding indicates that teacher preparation and professional development (PD) programs in international contexts and locally at TEIs must better support teachers to expand knowledge and develop skills not only for teaching SSIs, but also for other pedagogical approaches to promoting scientific literacy. While barriers to SSIs teaching in schools has already been explored in international research contexts, future research in Indonesia should explore the extent to which PD programs can support teachers with inadequate resources for SSIs teaching because some schools have less access to resources due to geographical location and population density (Faisal & Martin, 2019). This will be an important area for expanding access to innovations in pedagogical approaches in equitable ways throughout the country. In addition, as previous studies in Indonesian contexts have shown that research has tended to focus on examining the implementation of strategies in K-12 school contexts and with in-service teachers (Faisal, Gi & Martin, 2020) – it is recommended that funding agencies expand support for improving and innovating teaching and learning in TEIs and in pre-service teacher education.

Abbreviations

AB  attitudes and beliefs
CA  core aspects
SSIs  Socio-Scientific Issues
MOEC  Ministry of Education and Culture
PK  pedagogical knowledge
PCK  pedagogical content knowledge
TEI  teacher education institutions
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Ethical Consideration

Approval to conduct this study was granted by the Seoul National University Ethics Review Board. The data collected from this project were obtained with the necessary clearance from the partner institutions, guardians, and the students involved in the study. The names of the school and participants used in this study are all pseudonyms.

Publication Consideration

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