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Indonesian Pre-Service Science Teachers' Views on Socio-Scientific Issues-Based Science Learning

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Abstract

This study explores the views of Indonesian junior high school pre-service science teachers (PSTs) towards teaching based on socio-scientific issues (SSIs). Questionnaires were analyzed qualitatively and descriptively. The PSTs (N=62) acknowledged that student competencies ranging from personal to socially relevant skills as well as character formation can potentially be developed through SSI-based instruction. The PSTs mentioned several challenges which may hinder implementation of SSI-based instruction. These include the interdisciplinary and controversial nature of SSIs, a lack of familiarity regarding SSIs, the lack of necessary student skills, insufficient teacher expertise, and curriculum constraints. The PSTs viewed SSIs as able to potentially enhance their personal competencies through SSI-based instruction, mostly with regard to pedagogical skills. The relevance of SSI-based instruction was, however, not seen in as positive a light as the participants' views on the need of character building. The PSTs' intentions to later implementing SSI-based instruction ranged from medium to high.

Keywords: science education, curriculum, socio-scientific issues, pre-service science teachers

INTRODUCTION

Ever since the 1960s, the goals of school science education in many countries has shifted from a primary focus on preparing the next generation for science-related careers to achieving scientific literacy for all (Eilks, Rauch, Ralle, & Hofstein, 2013). Scientific literacy can be defined as the ability to recognize scientific questions and to utilize knowledge and skills from science. This includes making informed decisions regarding any science and technology related issues or problems in modern life and society. Approaches to achieving scientific literacy found in the literature suggest reorienting science learning along the lines of contexts relevant to everyday life (Childs, Hayes, & O'Dwyer, 2015) or using societal relevant questions (Hofstein, Eilks, & Bybee, 2011; Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). Socially-oriented science education focuses on a broader skill set which reaches beyond the learning of science. Some have suggested that it be organized using socio-scientific issues (SSIs). SSIs are science-related questions that are relevant to life in society and are multifaceted, controversial and open-ended in nature (Sadler, 2011a; Zeidler, 2015).

Knowledge of how to implement SSI-based instruction in Indonesia is limited. It seems that SSI-based science education is rarely implemented in Indonesia (Nida, Rahayu, & Eilks, 2020; Subiantoro, 2017). This study focused on the views of Indonesian pre-service science teachers (PSTs) in junior high school with regard to SSI-based teaching. It explored competencies suggested by the PSTs which should be enhanced through SSI-based education. The study inquired into PSTs' views on the connection of SSI-based pedagogies and student character building. It also asked about the suggested relevance of SSI-based pedagogies for junior high school students. The PSTs were required to suggest potential topics which might be good for carrying out SSI-based instruction in science education. The participants also listed potential challenges in implementing SSI-based learning and discussed their personal willingness to try out the corresponding lessons in the future.

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Contribution to the literature

- The findings of this research contribute to understanding potentials and challenges in implementing SSI-based science education as a new pedagogical approach in Indonesia.
- The study explores the connection of SSI-based science education and students' character formation and inquired into the relevance of SSI-based education for secondary school students.
- The study suggests to thoroughly implement SSI-based education in pre-service science teacher education and continuous professional development in Indonesia.

FRAMEWORK

One of the frameworks for SSI-based science education has been proposed by Sadler (2011b), which was further developed by Presley et al (2013). According to the framework by Sadler (2011b), SSI-based instruction consists of two core aspects, namely: *Design Element* and *Learner Experience*. Presley et al (2013) added *Teacher Attributes* as another core aspect. The Design Element consist of four features: 1) Instruction is built around a compelling issue; 2) the issue is presented first; 3) scaffolding for higher-order practices is provided (e.g. argumentation, reasoning, and decision making); and 4) culminating experience is provided, which could be done through multiple pedagogies, such as role play, debate, service learning, etc. This is in line with another SSI-framework called socio-critical problem oriented approach, developed by Eilks, Marks and others (e.g. Eilks, 2002; Marks, Bertram, & Eilks, 2008; Marks & Eilks, 2009, 2010). Under this framework, teaching has to be started with a societally-relevant, controversial, current, and authentic issue from the society which allows the learning of science content, while at the same time it engages students into group discussions and decision making processes. According to this approach, a fruitful socio-scientific issue must meet some specific criteria. The issue is authentic and relevant, since it is controversially discussed in the media with different points of view, such as newspaper, TV news, podcast, advertisement, etc. It should allow for open debate in the classroom in which arguments from science and technology may play a role. It is suggested that SSI-based science education starts with authentic media leading via science learning into decision making exercises.

Science teaching with the help of SSIs has been suggested as a way to potentially increase student interest and participation in science learning (Morris, 2014). In traditional science education, student interest has often been described as lackluster for many reasons. These include the beliefs that science content is difficult (Turner, Ireson, & Twidle, 2010) or that science is irrelevant (Sjøberg & Schreiner, 2005). The literature suggests that students can be motivated to learn science if they find the contexts provided for science learning to be personally relevant (Bybee & McCrae, 2011). However, what students perceive as relevant is not always in line with what teachers think is important (De Jong & Talanquer, 2015). Therefore, science teaching needs to be made relevant for all students by considering their personal interests and needs for the present and the future (Stuckey et al., 2013). Science learning should start from contexts connected to students' lives in society, their prior experiences, as well as their interests (Childs et al., 2015). SSIs represent a special form of context, because they are authentic, relevant and controversial in nature (Stolz, Witteck, Marks, & Eilks, 2013). SSI-based education is not merely another form of context-based science education, it aims centrally at promoting general educational skills which enable students to actively participate in a democratic society (Eilks et al., 2013, Eilks, 2015). SSIs can be used as a special form of context which motivates students to learn science. They can also serve as a starting point to practice skills which learners require to become scientifically literate individuals in a contemporary society (Sadler, 2011a, 2011b).

Furthermore, character formation and values education have been acknowledged to be a part of scientific literacy for the 21st century (Choi, Lee, Shin Kim, & Krajcik, 2011; Sjöström & Eilks, 2018). Character formation and values are assumed to be driving forces that serve as general points of reference for individuals to make responsible decisions regarding local or global SSIs (Choi et al., 2011; Lee, Chang, Choi, Kim, & Zeidler, 2012). SSIs have been suggested as a vehicle which can promote character formation and values education for global citizenship (Lee et al., 2013). Science education should be therefore linked to character-building education (Berkowitz & Simmons, 2003). It should also be integrated into citizenship education in order to promote the necessary skills for being responsible citizens (Sperling & Bencze, 2010). Teaching using SSIs is seen as having the potential to enhance students' moral sensitivity and contribute to their moral development (Fowler, Zeidler, & Sadler, 2009). It also provides students with chances to practice education for responsible citizenry (Zeidler & Nichols, 2009). In the case of Indonesia, the government has explicitly emphasized the need for moral character development through formal and informal education as stated in the Peraturan Presiden Republik Indonesia Nomor 87 Tahun 2017 (2017). In this framework, science education plays an important role in emphasizing character building as a part of formal education, for example

Table 1. Description of the questionnaire

Item	Question	Focus	Type
1	Challenges	Potential challenges to implement SSI-based education	Open-ended
2 & 3	Promotion of competencies/ skills	Learners' competencies or skills potentially enhanced through SSI-based education	Open-ended
		Teachers' competencies or skills potentially enhanced through SSI-based education	Open-ended
4 & 5	Character formation	Contribution of SSI-based education to learners' character formation	Likert type
		Reasons for the answer on item no.4	Open-ended
6 & 7	Relevance	Relevance of SSI-based education for learners	Likert type
		Reasons for the PSTs' answer on item no.6	Open-ended
8	Potential topics for SSI-based education	Potential topics to implement SSI-based learning from 33 main topics of the Indonesian junior secondary school curriculum	Multiple-select
9	Intention	Intention to implement SSI education when teaching in a school internship	Likert type

through the enactment of an SSI-based pedagogy to support character formation.

Research on SSI-based pedagogies is an emerging topic, but its implementation in Indonesia remains limited (Subiantoro, 2017; Nida et al., 2020). Studies exploring pre- and in-service science teachers' views of SSI-based learning have been published, but most are from outside Indonesia. Lee, Abd-El-Khalick, and Choi (2006) conducted a Korean study examining secondary school teachers' views on introducing SSI into the science curriculum. The results indicated that the teachers saw a need to address SSIs. However, only a small number of the participants actively used such issues in their own classrooms and the application was sporadic at best. The participants also mentioned several obstacles to teaching with SSIs such as a lack of time and the inaccessibility of relevant materials. Similar results were reported for Turkey by Kara (2012), who explored the perception of SSIs in the curriculum among biology teacher trainees.

In Indonesia, the number of studies examining science teachers' views regarding SSI-based science education is very limited. Subiantoro (2017) explored Indonesian senior high school biology teachers' views on SSI-based education. The findings reveal that before participating in the study, teachers had limited knowledge and experience regarding SSI-based learning. After being trained, their knowledge on SSI-based instruction had expanded and their views regarding the benefits and challenges of such an approach had changed. Similar results were recently found for Indonesian junior high school science teachers (Nida et al., 2020). This latest study covered teachers' views on SSI-based learning. Despite several challenges to implementation mentioned by the teachers, the participants expressed positive views on SSI-based instruction. They believed that SSI could contribute to students' skill set development and aid in character formation. Most of the teachers were also interested in implementing SSIs in their own classes and considered some potential science topics to incorporate SSI-based education.

Teachers are the key to curriculum change (Anderson & Helms, 2001). This holds true for in-service teachers. It is even truer for prospective teachers, since future teachers play a central role in enacting and spreading instructional innovation which they learn about in their teacher education programs (Davis, Petish, & Smithey, 2006). Inspired by the study previously done by Nida et al. (2020), we conducted a similar research focusing the pre-service junior high school teachers. The current paper details a study of PSTs in Indonesia with regard to the use of SSIs in science education. We examined the participants' views with respect to the potential benefits and challenges of SSI-based instruction to enhance skills and character formation. We also inquired into the relevance of learning about SSIs and investigated suggested topics for implementing SSI-based education, as well as the student teachers' intension to implement SSI-based instruction later when they become a science teacher.

METHOD AND SAMPLE

The study is based in a questionnaire adapted from Nida et al. (2020), with one multiple choice, three Likert and five open-ended items. At the beginning of the questionnaire, a definition and an example of SSI-based education is presented. This provides all the respondents with the same definition of what SSI-based education means. As a part of the questionnaire, the PSTs were asked about their knowledge of and familiarity with SSI-based education and any sources of information that they had used so far. An overview of the questionnaire with the different questions and foci (challenges, promotion of competencies/skills, character formation, relevance, potential topics, and intention of implementation) is provided in Table 1.

A total of 62 PSTs from Indonesia took part in the study. All of them were in the seventh semester of their university science teacher education program at a public university in East Java. There were 57 (91.9%) of the participants who were female and 5 (8.1%) who were male. This is not an unusual distribution in science teacher programs in Indonesia. All participants took part in the study voluntarily.

The Likert and multiple-choice items were subjected to descriptive statistics. The Likert items were scored on a scale from 0-4 (0 not at all; 4 to a very great extent). Mean values were calculated, with higher values

Table 2. PSTs' views on the challenge of implementing SSI-based education (% = PSTs mentioning)

No	Category	Description	Examples	%
1	Multidisciplinary/ multi-perspective nature	Any response related to the multidisciplinary, wider range of needed knowledge, up-to-date knowledge, or the ability to assess things from multiple perspectives	A wide range of knowledge is needed to implement this approach; this approach requires interdisciplinary knowledge; it is difficult to assess things from multiple perspectives.	38.7
2	Controversial nature	Any response related to the controversial nature of SSIs	Sometimes the controversial nature of a socio-scientific issue becomes a challenge that might impede the enactment of this learning approach; my concern is about the appropriateness of the controversial issue presented for the students; the controversies within SSIs might lead to differing positions; the issues (SSIs) might cause the discussion to go in multiple directions; some issues are very sensitive topics within society.	30.7
3	Unfamiliarity and missing expertise	Any response related to the teachers' low level of knowledge, skills and expertise in implementing SSI-based education	Teachers have limited knowledge and experience in implementing SSI-based instruction; teachers often focus only on delivering science content; I question teachers' ability to reach the science teaching goals by using SSIs.	27.4
4	Students	Any response related to students, such as missing competencies and low levels of motivation or awareness	Students have low levels of awareness regarding socio-scientific issues; students have low reading ability; students' low understanding of the scientific concepts which are very important for them to be able to discuss the issue; some students are not very familiar with the controversial issues which are currently found in society.	25.8
5	Curriculum	Any response related to the difficulty of integrating SSIs with the content in the curriculum	Not all science content can be taught using SSI-based instruction; sometimes it is difficult to integrate the SSIs with the content provided in the curriculum.	24.2
6.	Support	Any response related to support for SSI-based instruction	There are not enough learning materials available based on the socio-scientific issue.	3.2

indicating more positive views. The open-ended responses were qualitatively analyzed following Mayring (2014). The items were coded and categories developed. Initial categories were then developed cyclically based on the most frequent answers, checked against the data, and modified along a first analysis. The final coding was carried out independently by two researchers with an inter-rater reliability of 92.5%.

FINDINGS

Experiences

The majority of the participants in the study stated that they were not familiar with SSI-based science education (72.6%). Only 17 out of 62 respondents reported having read/heard/known about the topic. Most of these people had been introduced to SSI-based education through either journal articles or colleagues. None of them had received knowledge on SSI-based education during their teacher education courses.

Challenges in Implementing SSI-based Learning

Six categories of challenges in implementing SSI-based instruction could be identified (Table 2). The two most common challenges were related to the multidisciplinary character and controversial nature of SSIs. The other problems mentioned included teachers' lack of familiarity with the topic, too little expertise in implementing SSI-based education, an estimated lack of student competencies, and challenges related to matching up or integrating SSIs into the science curriculum.

Competencies

The PSTs suggested several competencies that might be developed through SSI-based education, not only for the learners but also for the teachers. Student competencies mentioned by at least 10% of the PSTs were sorted into categories. These included problem solving, critical thinking, higher-order thinking, communication, character, interconnecting science-technology-society-environment, collaboration and curiosity (see Table 3). Further competencies mentioned by less than 10 % of the PSTs included creativity, scientific reasoning, scientific literacy, scientific inquiry, content knowledge, the nature of science, and decision-making skills.

Aside from considering learner competencies that can be enhanced by SSIs, the PSTs also mentioned competencies that can potentially be developed among teachers. The most commonly mentioned ones fell into eight categories. These include designing innovative contextual learning, attaining wider knowledge, increasing teaching skills/classroom organization, gaining multidisciplinary knowledge, adding teaching skills, promoting creativity, maintaining neutrality,

Table 3. PSTs' views on competencies which learners can potentially develop (% = PSTs mentioning)

No	Category	Description	Examples	%
1.	Problem solving	Any response related to problem solving skills	The students learn to solve a problem scientifically and also consider societal needs.	43.5
2.	Critical thinking	Any response about reflexive and critical thinking	Students can enhance their critical thinking skills; the students can reflect upon information regarding the SSI so that they can make an informed choice or decision.	41.9
3.	Higher order thinking skills	Any response related to higher order thinking skills based on Bloom's taxonomy	Higher order thinking skills; the ability to analyze the problem within society.	27.4
4.	Communication	Any response about communication skills	The ability to convey ideas, criticize, answers, and ask questions; the ability to present data using tables, charts, etc.; the ability to ask/answer questions, or to get involved in a discussion.	25.8
5.	Character	Any response related to character formation	The ability to show positive attitudes regarding the SSI such as open-mindedness, appreciating different opinions, enhancing positive attitudes and building character.	17.7
6.	Multidisciplinary nature	Any response related to interconnection science-technology-society-environment or related to multidisciplinary nature of SSIs.	Connecting what the students learn at school with society; implementing scientific knowledge in society.	14.5
7.	Collaboration	Any response related to collaboration either within the community or society at large	The students know how to work together with society to solve a problem using a win-win solution to the controversy.	11.3
8.	Curiosity	Any response related to curiosity	Increase learners' curiosity and interest in learning science.	11.3

Table 4. PSTs' views on competencies teachers potentially develop (% = PSTs mentioning)

No	Category	Description	Examples	%
1.	Designing innovative contextualized learning	Any response related to the ability in context-based learning by utilizing SSIs and integrating SSIs with the curriculum	Choosing suitable issues for science topics; the ability to analyze societal problems and integrate them with learning activity by providing real life examples/contexts; the ability to integrate science/technology and society and make it a learning activity; the ability to enhance students awareness about societal issues; the ability to design science learning based on real-life problems.	46.8
2.	Wider knowledge	Any response about enhancing knowledge	Teachers can gain a wider range of knowledge; they have up-to-date information.	21.0
3.	Teaching skills/classroom organization	Any response related to abilities in teaching or organizing the classroom	The ability to organize discussion and fruitful debate; the ability to help students think of and propose ideas to solve the problems faced within society; skills in directing the discussion so that students can take a position regarding the issue; the ability to utilize the issue in the discussion so that the students can analyze the problems; the ability to direct students in thinking critically regarding the issue; the ability to simplify the complexity of the SSI so that the students can follow the instructions easily; the ability to motivate students in discussions; the ability to choose suitable teaching models for SSI-based learning.	22.6
4.	Multidisciplinary knowledge	Any response about inter- and multidisciplinary knowledge	The ability to relate/connect science with other disciplines.	16.1
5.	Creativity	Any response about creativity	Creativity in presenting the issue to be an interesting topic for the students to discuss	9.7
6.	Neutrality	Any response about the teachers' neutral position	The ability to be neutral to the different positions, so that the teachers' personal beliefs do not interfere with students to finding a position; the ability to be open and facilitate students presenting different positions in dealing with the SSI	6.5
7.	Utilizing learning resources	Any response related to providing learning resources for students	The teachers' ability to provide students with access to learning resources which support this approach; providing students with suitable media for learning.	4.8
8.	ICT	Any response about the ability in utilizing ICT	The ability to develop and utilize ICT-based media for teaching; the ability to access information through ICT-based media.	4.8

utilizing learning sources, and bettering information and communication technology (ICT) skills (see Table 4).

Table 5. PSTs views on character formation and relevance

Aspect	Number of response	Score*					Sum	Mean value	Standard deviation
		0	1	2	3	4			
Character	62	0	0	9	18	35	212	3.42	0.74
Relevance	62	0	1	17	36	8	175	2.82	0.67

*0: not at all, 1: to a small extent, 2: to some extent, 3: to a great extent, 4: to a very great extent

Table 6. PSTs' justifications concerning character formation (% = PSTs mentioning)

No	Category	Description	Examples	%
1.	Awareness	Any response related to awareness, either social or environmental	Students can become more aware of the problems occurring in society; students become aware of their environment; students take more care of others.	22.6
2.	Open mindedness	Any response related to open-mindedness and respecting others' views	Students become more open to different opinions; conveying ideas critically in a polite manner.	22.6
3.	Real world examples/contexts to strengthen character formation	Any response about SSIs being real life contexts for addressing societal problem as well as strengthening character	Through SSIs, we can connect science with real life phenomena in society that can be used to strengthen character formation.	21.0
4.	Responsibility in making decision	Any response related character in decision making and to take a position	Students would be wise to face/react/take action/decision regarding societal problems; students think twice before they choose an action; when SSIs are implemented, students can learn science through them, as well as learning to take a position in their society; students can make responsible decisions; students can think scientifically when they need to face different arguments	17.7
5.	Problem solving	Any response related to problem solving	Students can be provoked to find solutions about a societal problem; students can identify problems in their society and try to find a solution to those problems	14.5
6.	Appreciation of values and ethics	Any response related to values and ethics	Students can appreciate values which come from their culture.	11.3

*0: not at all, 1: to a small extent, 2: to some extent, 3: to a great extent, 4: to a very great extent

Character Formation and Relevance

The PSTs' views regarding SSI-based education as a contributor to character growth and its relevance for the students were scored from 0 to 4. Zero was rated as "not at all". A value of four meant "to a very great extent". All of the PSTs perceived SSI-based education positively. Most of them thought that SSI-based education can contribute to building learners' character to very great extent. The mean value for this item was 3.42 (Table 5). Most of the PSTs saw SSI-based learning as being relevant to the students. However, SSI relevance for students did not score as positively as character building did. The mean value for relevance was 2.82 (Table 5). Table 5 also shows the comparison between the PSTs' single answers on character formation and how relevant SSI-based education is.

The reasons for PSTs' positive views on character formation fall into six categories (Table 6). These categories represent aspects of character that can potentially be enhanced or expanded. These include student awareness, open-mindedness, real world examples/contexts to strengthen character formation, responsibility in decision-making or taking a position, problem solving, and appreciation of values and ethics.

The PSTs' responses to the relevance of SSI-based learning for students were classified into six categories (Table 7). The participants who had positive views indicated that SSI is relevant for students because it is often connected to daily life. They viewed SSI as interrelating science / technology and environment / society. SSI can possibly enhance the multidimensionality of skills / competencies. Such topics are also controversial in nature and are currently being debated in society at large. The respondents who saw SSI-based education as less relevant suggested the controversial nature of SSIs could also be a negative aspect. One reason for this is that pros and cons can arise which make a topic difficult to handle. Another reason mentioned was that this approach cannot be applied to all topics in the science curriculum.

PSTs Intention to Implement SSI-based Education

The PSTs' intentions of implementing SSI-based education was also scored on a scale from zero to four. Intention was defined as a participant's willingness to implement SSI-based education should they be asked later in the teaching internship program. The mean value of the PSTs' intentions was generally positive with a value of 2.76 (Table 8). This was less positive than the mean values found for the contribution of SSI-based

Table 7. PSTs' answers concerning relevance (% = PSTs mentioning)

No	Category	Description	Examples	%
1	Real life contexts/ issues / problems	Any response about SSIs being real life contexts or problems faced by society that can be observed by the students, interest them, and can be used to provoke discussion	SSI-based learning is about the problems currently faced by society; it is not like the textbook; this approach is based on exploration of their environment by the students; students are directed to think about the issue so that they can be more actively involved in the discussion; the issue is very close to students' lives and that makes them more interested.	43.5
2	Interrelatedness of the issue with science/ technology/ environment/ society	Any response about the interrelatedness of the SSI with science/technology and environment/society that enhances students' knowledge	Students might connect the scientific and environmental issue; the issue can be used to discuss other aspects such as economics, culture, science, etc. under one topic and is suitable for integrated science learning; students can analyze the issue through multiple perspectives that the students provide and that brings wider knowledge.	30.6
3	Enhances multiple dimensions of competencies	Any response related to SSI's role in enhancing multiple dimension of students competencies, either thinking skills, problem solving skills, critical thinking skills, cognitive, affective, psychomotor, etc.	Students might enhance their cognitive, affective, psychomotor skills; students might enhance their higher order thinking skills, which are needed for their professional work in the future; this approach can be used to strengthen character formation; students can increase their critical thinking skills; students learn to solve problems scientifically.	16.1
4	Controversial nature	Any response related to the controversial nature of SSIs	It is the controversial nature that I think will not work (for the students); there will be pros and cons and it is difficult to get a win-win solution; the controversial nature can make students more aware of the issues and make them try to analyze and discuss it.	8.1
5	Currently being under debate	Any response related to SSIs as being current topics of discussion in society	The issue is currently being discussed by society; the issue is not new for the students.	6.5
6	Not all content can be taught using SSI-based education	Any response related to unsuitability for the whole curriculum	Not all material can be adapted to this approach; not all topics are suitable for SSI-based learning.	4.8

Table 8. PSTs' willingness to implement SSI-based education

Aspect	N	Score*					Sum	Mean value	Standard deviation
		0	1	2	3	4			
Intention	62	0	0	28	21	13	171	2.76	0.78

*0: not at all, 1: to a small extent, 2: to some extent, 3: to a great extent, 4: to a very great extent

learning towards character formation (3.42) and SSI relevance (2.82) (see Table 5). The PSTs' willingness to implement SSI was less positive than the other categories. However, we should note that none of the PSTs replied negatively to implementing SSI-based education. The majority said that they would implement SSIs to some or to a great extent. Some PSTs even said that they would do so to a very great extent.

Potential Topics to Incorporate SSIs

The participants named several topics which they considered to be helpful for incorporating SSIs into teaching practice (Table 9). There are ten topics in the lower secondary school science curriculum in Indonesia which were suggested by at least one-third of the PSTs. The topics are mostly related to environment or technology.

Table 9. Potential science topics for SSI-based instruction

No	Topic	%
1.	Environmental pollution	82.3
2.	Global warming	80.6
3.	Food biotechnology	71.0
4.	Green technology	66.1
5.	Addictive and additive	62.9
6.	Civilization and environment	48.4
7.	Interaction of living things and environment	46.8
8.	Electricity and electrical technology in the society	40.3
9.	Heredity	37.1
10.	Energy in life systems	33.9

DISCUSSION AND CONCLUSION

SSI-based education was relatively unknown among the Indonesian PSTs in this sample. They had limited knowledge and experience about utilizing SSIs to teach science. All of the participants had had a course on science-technology-society. However, most of them had no experience prior to this study with approaches based

in authentic and controversial SSIs as a basis for science education. Theoretical justifications and conceptual ideas on the inclusion of SSIs in science based education are needed in science teacher education for later implementation (Sadler, 2011a). This also seems to be the case for Indonesia. In a study by Nida et al. (2020), practicing teachers described students' lack of competency in dealing with SSIs as the largest expected challenge in implementing SSI-based education. Among the PSTs, the multidisciplinary and controversial nature of SSIs was listed as the largest challenge to teaching, since the units incorporate a variety of societal factors ranging from politics to economics to ethics (Sadler, 2011a). This was, however, also mentioned by many in-service teachers in Indonesia in the study by Nida et al. (2020). This was also paralleled in a Thailand study published by Pitiporntapin, Yutakom and Sadler (2016), in which PSTs tended to prefer uncontroversial issues for students to learn science. The PSTs in this study said that the controversial nature of SSI is not familiar to students. This avoidance of controversial issues might not just be due to teachers' views of their students. Teachers often do not address controversial science-related issues because they themselves do not have a clear position (Lee et al., 2006).

The findings above suggest that teacher education needs to more thoroughly incorporate not only the learning *of* science, but also *about* science and its inter-relatedness to other disciplines. Teacher trainees also need to learn about scenarios and pedagogies for effectively dealing with controversies in education, for example structuring discussions or role-playing. Both learning about multidisciplinary SSIs and covering how to deal with controversies are needed, if we intend to lower the barriers for effectively implementing SSI-based education. This will remain a challenging task for teachers, as Owens, Sadler and Zeidler (2017) suggest:

"*Introducing students to relevant and contentious issues, helping them contextualize science ideas and practices toward the resolution of the issue, and tasking them with creating effective arguments and evaluating those of their peers is critical for promoting the kind of civil discourse that democracy requires, but it can be a daunting task for teachers*" (p. 47-48)

Although the PSTs from this sample listed several challenges in implementing SSI-based education, they also acknowledged that many competencies might be promoted among both students and teachers. The first three competencies mostly acknowledged by the PSTs were problem-solving, critical thinking, and higher-order thinking. These three skills can be generalized into higher-order thinking skills that can be defined in term of transfer (the ability to use the knowledge in a more complex ways), critical thinking (reasonable reflective thinking focused on deciding what to believe or do), and problem-solving skills (the ability to identify and solve problems in life), as suggested by Brookhart (2010). Following Holbrook and Rannikmae (2007), the skills promoted by societally-oriented science education by the PSTs cover both the individual and societal domain. In the individual domain, intellectual skills, such as problem-solving, critical thinking or communication skills are believed to be enhanced by SSI-based learning. In the societal domain, understanding the interlinkage of science-technology-society and collaboration skills might be fostered. A few of the PSTs also acknowledged advantages for the nature of science domain by promoting inquiry or scientific investigation skills, scientific reasoning, or understanding the nature of science. Most of the skills mentioned by the PSTs were also in line with the those acknowledged by the in-service teachers in the previous study by Nida et al. (2020), although with slightly different order.

The PSTs also recognized several competencies that teachers might develop if SSIs are used in teaching. The most frequent responses were related to pedagogical skills such as designing innovative contextual learning, classroom organization and teaching skills, and utilizing various learning resources in teaching. This is also similar with the in-service science teachers' responses about the teachers' skills that are potentially enhanced (Nida et al., 2020). Most of the skills the in-service science teachers mentioned were related to pedagogy. Everyday issues which frequently appear in the news or media, commonly about environment, energy, and resources (e.g. SSIs) have all been suggested as daily life contexts to relate science to students' daily life (Childs et al., 2015). SSIs therefore may affect learner motivation, orientation, topic illustration, and material application as suggested by De Jong (2008). SSIs seen to provide a motivational function for students, because they are strongly related to one's personal and societal life. Teachers also utilize SSIs as contexts for their students to learn science concepts, although it is clear that not all traditional science content can be covered with SSI-based education. The PSTs, however, did acknowledge that SSI-based learning requires them to acquire a wider range of knowledge and skills, such as multidisciplinary knowledge and the ability to develop and utilize ICT-based media for teaching. This has also been suggested by Morris (2014), Evagorou (2011), and Presley et al. (2013). Additionally, better skills at forming networks of students, teachers, experts and other members of societal groups might be needed (Chen, Seow, So, Toh, & Looi, 2010). Less often mentioned, but also necessary, is the development of a stance of neutrality regarding different positions. This ensures that teachers' personal beliefs do not interfere inadequately with the students' positions.

A very important point for the PSTs was the potential role of SSI-based education in influencing students' character formation. This was valued more highly than the relevance of students to learning about SSIs. One reason might be in the explicit focus of character education in the official Indonesian educational policy

(Peraturan Presiden Republik Indonesia Nomor 87 Tahun 2017, 2017). Generally, it has been suggested that SSI-based education could play a role in developing character and imbuing values as global citizens (Lee, et al., 2013), such as in making responsible decisions and taking action on global issues (Lee et al., 2012). SSI-based education was seen to contribute to certain aspects of character formation, such as awareness, open-mindedness, as well as responsibility. These aspects of characters were also the three most acknowledged characters by in-service science teachers (Nida et al., 2020).

Because SSIs are viewed positively in regard to building character and being relevant to learners, they are also desirable to most teachers. The participants in this study tended to want to employ SSI-based education in the future. Whether this will lead to implementation of SSI-based education must be viewed with caution, since it faces many hindering factors. This is especially true for the question of whether or not junior high school students have sufficient skills for dealing with controversial issues. Missing skills were also reported in a study published by Kara (2012) in Turkey, where PSTs were concerned that their students were not mature enough to make judgments regarding SSIs. Ekborg, Ottander, and Silfver (2013) also reported that teachers tend to think that school students are too young and have too little prior knowledge and experience in handling SSIs. One controversial belief among teachers about the level of skills and knowledge necessary for understanding controversial SSIs can be found in a study examining teachers' views regarding teaching climate change in Germany (Feierabend, Jokmin, & Eilks, 2011). All this must be considered, however, to be less a question of students' skills and more an issue of adequate pedagogies and teachers' investment in their pupils' skills development.

This study is somewhat limited by its sample size and its focus on only one group of PSTs from Eastern Java. However, the results may help us to better understand Indonesian PSTs' views regarding the challenges and potential of SSI-based education. The study suggests that SSI-based education needs to be more thoroughly inserted into PSTs teacher pre-service education and continuous professional development. To implement this, the development and dissemination of examples, resources, and support structures are needed to overcome some of the expected difficulties (Mamlok-Naaman, Eilks, Bodner, & Hofstein, 2018). The program needs to provide PSTs with examples of how SSIs can be incorporated into science class using issues relevant to the Indonesian context. Then they can experience the corresponding practices themselves in teaching and during their teacher education seminars. The examples could start with the topics mentioned by PSTs or in-service teachers (Nida et al., 2020) which are believed to have potential, such as environment pollution, global warming, food biotechnology, green technology, etc.

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