A Survey of Indonesian Science Teachers' Experience and Perceptions toward Socio-Scientific Issues-Based Science Education

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Abstract: This survey explored Indonesian science teachers' experience and perceptions toward science teaching that is based on socio-scientific issues (SSIs). The participants were asked whether or not they already used corresponding practices in their own teaching and whether they experienced any challenges in implementing SSI-based pedagogies. Further focal points were the teachers' views on student competencies that can be fostered through SSI-based education, the connection of SSI-based pedagogies with students' character formation, potential topics for implementing SSIs in science education, and the teachers' interest in such implementation. Data were collected with the help of a questionnaire that was administered to 99 science teachers. This was then followed up by interviews with 20 intentionally selected teachers taken from the overall sample. The study revealed that teachers' familiarity with SSI-based pedagogies varies greatly. Regardless of their familiarity with the term, some of the teachers had already implemented corresponding practices at varying levels of intensity. Although almost all of the participants saw potential in SSI-based pedagogies for increasing student competency development and character formation, most of the respondents did not implement SSI-based teaching very often in their lessons. They mentioned several challenges that hindered them in implementing SSI in their teaching practices. Reasons included the lack of necessary students' competencies, a lack of teacher expertise, the content in the official curriculum, inadequate facilities, and a lack of time for lesson preparation and implementation. When asked for ideas in implementing SSI-based education, teachers basically suggested topics related to the environment or technology as suitable for SSI-based education. In spite of the many challenges, most of the teachers were still interested in implementing SSIs in their classes.

Keywords: science education; scientific literacy; socio-scientific issues; teachers' perceptions

1. Introduction

1.1. Background

Relevant science education focuses on the enhancement of scientific literacy among learners, which covers a broad range of goals [1]. Exactly what modern, scientific literacy-oriented teaching should include, however, is under constant debate [2]. Roberts described two visions of scientific literacy [3]. Roberts' first vision focuses on the conceptual understanding of science content for later application, e.g., in science-related professions. The second view stresses the fact that science learning should

be contextualized in order to understand how meaningful science is for life and society. Recently, Sjöström and Eilks suggested a third, critical view that highlights the development of general skills for personal and societal development through science education [2].

The results of the Program of International Student Assessment (PISA) indicated that Indonesian students' scientific literacy remains among the lowest tier of teaching success [4]. In order to promote students' scientific literacy to reach the third vision by Sjöström and Eilks [2], there needs to be a way to simultaneously make students competent and prepare them to be involved actively in socio-scientific controversies [5]. Zeidler and Lewis believe that scientifically literate individuals should be able to make informed decisions about socio-scientific issues (SSIs) that are regularly faced by modern, technologically advanced societies [6].

Science education is significant when preparing future citizens to make informed decisions about science-based discourse in the modern world; therefore, learners should be facilitated with the environment (or context) to practice all the skills they require to be actively involved in SSI discourses, as well as learning the science content behind a given issue [7]. Science educators need to consider the context created for learners when they experience science in school [8]. However, teachers often introduce science topics with only oblique references to the everyday lives of their students [9]. Socio-scientific issue (SSI)-based learning provides relevant contexts that students might need to confront, negotiate, and decide upon in everyday-life situations linked to science and technology [7]. SSI-based education is not only a specific form of context-based learning for science education but also a framework promoting general educational skills for preparing students in order to be actively involved in a democratic society where they need to make informed decisions about SSIs [10]. This direct link to societal issues is, however, still neglected in many countries [11].

In Indonesia, SSI-based teaching can be considered as a new instructional approach in science education, so that there is a need to know how teachers perceive this teaching innovation [12]. Subiantoro recently conducted a study on the implementation of SSI-based instruction in Indonesian senior secondary schools [12]. He examined biology teachers' perception regarding SSI-based instruction. The results of the study showed that before participating in a teacher professional development program about SSI based-instruction, the teachers considered SSI-based pedagogy as a new concept. However, after taking part in the SSI-teaching professional development program the teachers had a basic insight on the necessity of SSI-teaching and deepened their knowledge about the advantages and challenges in implementing SSI-based teaching. To date, no further surveys on the situation in Indonesia concerning SSI-based science education are available. This is also true for Indonesian junior secondary science education (grades 7–9). The present survey explores science teachers' views regarding SSI-based teaching and learning in Indonesian junior secondary schools. It focuses on how practicing teachers in Indonesia perceive SSI-based pedagogies with regard to their potentials and challenges in grades 7–9.

1.2. Theoretical Framework

Zeidler provides several useful characteristics of fruitful SSIs [13]. They should contain: (1) controversial and ill-structured problems that require scientific, evidence-based reasoning to make informed decisions; (2) social ramifications for scientific topics that require students to get involved in dialogue, discussion, debate, and argumentation; (3) implicit and explicit moral aspects requiring, at least to some degree, moral reasoning skills; and (4) factors associated with the formation of personal virtue and character as a long-range pedagogical goal. Marks and Eilks [14] have previously suggested several criteria for selecting fruitful SSIs for science learning. These include authenticity, relevance, a controversial character, openness to debate, and relatedness to science and technology. Based on SSIs developed using these criteria, the socio-critical and problem-oriented approach to science teaching was described by Marks and Eilks [14]. Several case studies showed how skills necessary for developing critical scientific literacy, such as communication and evaluation skills, can be developed among learners [15–18]. Such skills are very important in educating responsible citizens

for the future [11]. Moreover, SSI-based science education is a microcosm within society, in which discourse, argumentation, and decision-making represent important tools [19] for learners to develop cognitive, ethical, moral, social, and emotional skills [20]. In general, SSI-based instruction is one that utilizes SSIs as a focal point to drive the students to learn science aspects related to the issue, as well as to discuss any societal aspects.

SSI-based science education has the potential to foster personal cognitive and moral development in order to promote functional scientific literacy in students [13,21]. SSI-pedagogies exceed traditional teaching practices in the way that they encourage students to highlight multifaceted factors such as interpreting issues, making decisions, solving problems, and engaging in argumentation [21]. The controversial nature of SSIs can also be used as a tool to challenge students to suggest action and to recommend compromises or solutions based on scientific concepts [22]. It can also be used to justify learners' decisions, based upon normative beliefs related to ethical considerations [13]. In addition, Zeidler and Sadler have stressed that one of the long-term goals of SSI-based education is the formation of character [21]. Character formation under their SSI-framework is conscience-building, which is accomplished through a process of reflexive thinking.

There are some studies regarding teachers' perception about SSI-based pedagogies. Lee et al. examined Korean secondary science teachers' perception about introducing SSIs into the science curriculum [23]. The participants had positive views about addressing SSI's although only a few teachers operated SSI-based teaching in their classrooms. Moreover, the teachers mentioned lack of time and the unavailability of supporting materials to be the main difficulties that hindered them in teaching with an SSI-based approach. Challenges in implementing SSI-based teaching were also reported by Bosser et al. [24]. They described a conflict between implementing student-centered practices through SSI and the achievement of traditional learning goals.

The major challenge in implementing modern, student-centered teaching, including SSI-based instruction, in Indonesia is the strong emphasis on the national examinations. Teachers see difficulties between SSI-based teaching and the strong orientation on content knowledge in the curriculum to ensure students' success in the national examinations [12]. Nevertheless, Subiantoro described in the case of senior secondary biology teachers that despite all the challenges in implementing SSI-based instruction teachers are interested in SSI-based teaching because they consider students to become more motivated in science learning by SSIs [12]. Lee and Chang suggested two main issues of motivation in teaching along SSIs [25], one concerned higher motivation among teachers and the other motivational benefits among students. Yang et al. found that most science teachers believe that addressing SSIs in science classes is reasonable to cover elements of creativity and character formation [26].

To better understand the limited emphasis given to SSIs in junior secondary classrooms in Indonesia, this study aimed at examining Indonesian secondary science teachers' perception of SSI-based instruction and of teaching about SSIs in their classrooms. The guiding research questions in this study were:

1. Do Indonesian junior secondary science teachers incorporate SSI-based instruction in their teaching practices?
2. What are Indonesian junior secondary science teachers' views about incorporating SSI-based instruction in their classes?

To answer the first research questions, Indonesian junior secondary science teachers were asked whether or not they have known/read/heard about the concept of SSI-based teaching and, in case they have, what the source of information regarding SSI-based instruction was. The teachers were also asked whether/how often they have implemented SSI-based instruction in their classes. For the teachers' views on SSI-based teaching, the teachers were asked which competencies can be developed by SSI-based teaching among students and teachers, what aspects of students' characters formation might be enhanced, which topics are suggested to integrate SSIs in science education, and what challenges might hinder teachers in implementing SSI-based teaching. Finally, teachers' interest to implement SSI-based teaching in their science classes was explored.

2. Materials and Methods

2.1. Participants

This study was based on a questionnaire survey distributed to 109 participants of a science forum in East Java, Indonesia, in 2018. Ninety-nine science teachers of junior secondary schools voluntarily filled out the questionnaire. Following the questionnaire survey, interviews were conducted with selected teachers from the sample. After an initial screening of the questionnaires, 20 teachers were chosen based on the variety of their personal data and answers in the questionnaire. The interviews were conducted two weeks after the questionnaire survey in order to deepen the findings from the questionnaire.

In the questionnaire, the respondents were asked to describe their personal backgrounds, including teaching qualifications, teaching institutions, and teaching experience. The 99 teachers worked in 74 different schools and had varying educational backgrounds. Some of the participants taught in public secondary schools. Others worked in the private schooling sector. Nine of the teachers did not specify any affiliation. Details of the educational background, affiliation type, and teaching experience are given in Table 1.

Table 1. Background of the participants (N = 99).

Aspect	Profile	Number of Teachers
Educational background	Bachelor's degree (99) in:	
	Biology	19
	Biology education	36
	Chemistry	5
	Chemistry education	2
	Physics	8
	Physics education	22
	Science education	7
	Master's degree (38) in:	
	Biology education	2
	Physics education	22
	Science education	4
	Social education	1
	Management	5
	Chemistry	1
	Chemistry education	1
	Educational policy and development	2
School type	Private junior secondary school	31
	Public junior secondary school	59
	Teachers who did not specify the school affiliation	9
Teaching experience	0–5 years	32
	6–10 years	22
	11–15 years	23
	16–20 years	9
	More than 20 years	13

2.2. Questionnaire

The main part of the questionnaire concerned the teachers' views toward SSI-based science education. To provide an overarching definition of what SSI-based learning is, the questionnaire provided both a description and an example of SSI-based learning. SSI-based learning was defined as the pedagogy that utilizes controversial, complex issues related to science and technology; requires scientific and moral consideration; can be viewed from multiple perspectives and could have more than one possible solution. SSI-based teaching was described not only to direct students' learning of science concepts behind any given issue but also to deal with societal discourse, e.g., by analyzing

pros and cons, assessing risks and benefits, and informing about decision-making. By the description and example of SSI-based teaching, it was assumed that the participants received a common point concerning the nature of SSI-based instruction.

The questionnaire was pretested with 34 teachers to guarantee the comprehensibility of the instrument before the study. The final questionnaire consisted of ten items, mostly open-ended (questions no. 4, 5, 6, and 8), and Likert-type questions (5 steps; ranging from "not at all/never" to "a very great extent/always"), depending upon the question (questions no. 3, 7, 10). The other types of questions included yes/no answers (question no.1) and multiple-choice formats with more than one potential response (questions no. 2 and 9).

The first three items in the questionnaire asked about teachers' personal experiences concerning SSI-based teaching. The next seven items regarded their views on the corresponding approaches. The questionnaire contained the following aspects:

(1) The teachers' familiarity (whether or not they have known/heard/read something) with SSI-based pedagogies
(2) Their source(s) of information,
(3) How often they had implemented SSI-based teaching,
(4) Any suggested challenges in implementing SSI-based teaching,
(5) Any student competencies that might be boosted by using a corresponding approach,
(6) Any teacher skills that can be developed,
(7) To what extent SSI-based teaching can contribute to character formation,
(8) Which aspects of character formation can be most significantly supported,
(9) Suggested science topics useful for implementing SSI-based teaching,
(10) To what extent the teacher remained interested in implementing SSI-based teaching in spite of any suggested challenges.

2.3. Analysis

All answers were transcribed and analyzed descriptively. The analysis of the open questions and the interview data was performed following the basic tenets of qualitative content analysis according to Mayring [27]. The responses to the open-ended questions were coded and counted according to categories inductively derived from the data. The analysis of the questionnaire data was later illustrated and enriched by responses from the follow-up interviews.

3. Results

3.1. Teachers' Experiences Regarding SSI-Based Teaching

The number of teachers who had never heard or read about SSI-based teaching and learning exceeded (53.3%) those who had previously heard about it (46.6%). At every level of teaching experience, more teachers were unfamiliar with the SSIs as an educational concept than those who had already heard of it, except the group of teachers with less than five years of teaching experience (Figure 1).

The teachers with previous knowledge about SSI-based teaching received their information from various sources. The two most common sources were colleagues and articles in teacher journals (each had a value of 41.9%). Other sources included workshops, the Internet, book chapters, and papers from teacher conferences (Figure 2).

Personal experience with implementing SSIs in science education also varied greatly. Almost 30% of the teachers had never implemented SSIs in their classes. Even among those who had previously heard of the approach, some had not implemented it. There were, however, some teachers who stated that they never heard about SSI-based education at the theoretical level but have used a corresponding approach in their classes. Altogether, a total of 64.6% of the participants never or rarely implemented

SSIs in their teaching, only 25.3% did so occasionally, and a mere 10.1% stated that they did so regularly. None of the teachers stated they used SSI-based teaching for the whole curriculum (Figure 3).
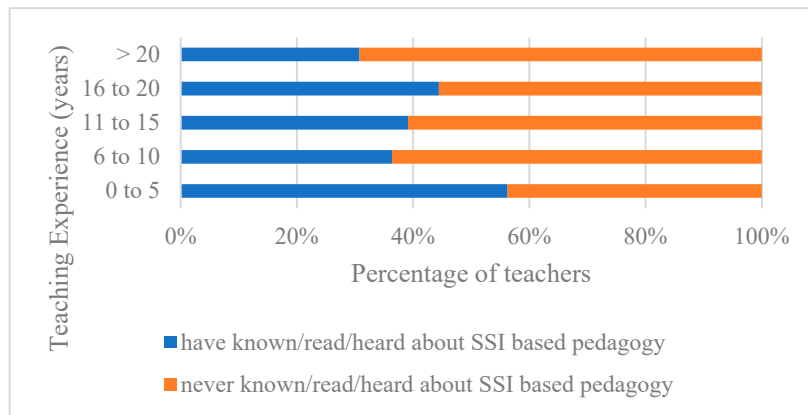

Figure 1. Teachers' general knowledge about socio-scientific issue (SSI)-based education.
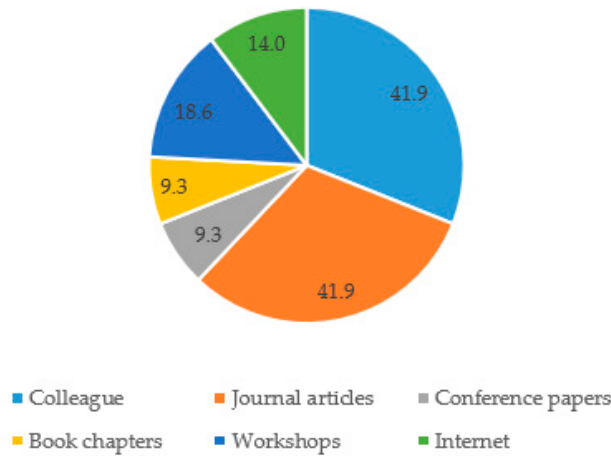

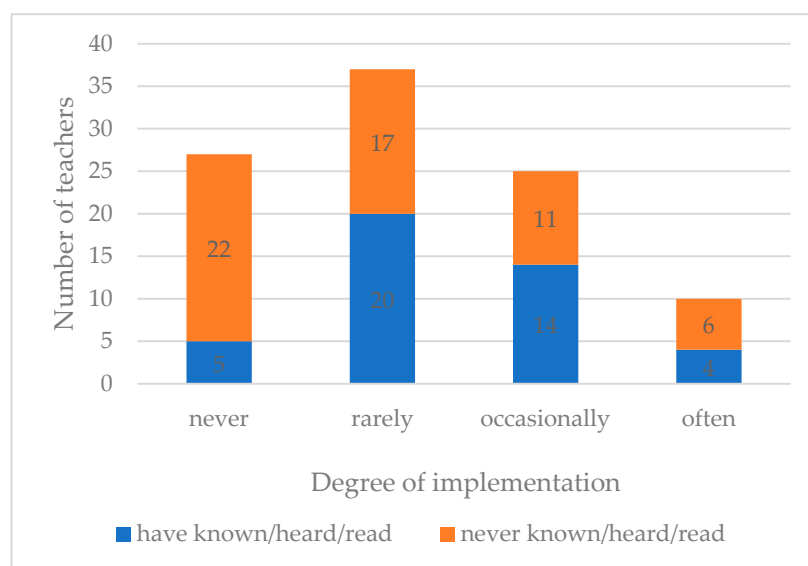**Figure 2.** Sources of information on SSI-based science education.

Figure 3. Frequency in implementing SSI-based learning.

A lack of implementation among those teachers who rarely/never implemented SSI-based learning in their classes might be generally caused by the focus of their teaching. For these teachers the science content seems to be the basic goal, not discussing any associated controversies, as stated in the following interview excerpt: "*I have used the food issue to talk about food ingredients, such as nutrients and food additives, whether the food is healthy or not. I ask the student to check the food ingredients on the label and to identify the function and risk of the ingredients. The discussion was mostly about the ingredients rather than any societal discussion. I also address the risk of additives, such as preservatives, coloring agents, sweeteners, etc., but we do not discuss any associated controversies.*"

3.2. Teachers' Perceptions Regarding SSI-Based Science Education

The teachers suggested several ideas for competencies that might be developed through SSI-based learning, both for learners and teachers. These suggestions could be categorized into the areas of communication, problem-solving, critical thinking, scientific inquiry skills, social and environmental awareness skills, literacy, higher-order thinking skills, creativity, and collaboration skills (Table 2). A few competencies were mentioned by single teachers and included open-mindedness and curiosity.

Table 2. Suggested learner competencies that might be developed when implementing SSI-based teaching (% = teachers mentioning).

No.	Competence	Description	%
1.	Communication	Any response related to students' ability in communication, argumentation, discussion, or debate	33.3
2.	Problem-solving	Any response related to problem-solving	32.3
3.	Critical thinking	Any response related to critical thinking, reflection, or decision-making processes	23.2
4.	Scientific inquiry	Any response related to skills needed to conduct scientific inquiry	21.2
5.	Social and environmental awareness	Any response related to awareness of the environment or problems faced by the society	14.1
6.	Literacy	Any response related to literacy (reading, science literacy, scientific literacy)	12.1
7.	Higher-order thinking	Any response that covers higher-order thinking skills based on Bloom's taxonomy	12.1
8.	Creativity	Any response related to creativity	11.1
9.	Integrating science–technology–society	Any response regarding the ability to integrate science with life, technology, or society	10.1
10.	Collaboration	Any response about working together/collaboration	8.1

Aspects of communication and problem-solving are the skills most often suggested by teachers to be developed when SSI-based teaching is implemented, followed by critical thinking and scientific inquiry. One teacher stated in the interviews that students are very engaged in the SSI discussions: "*I used the issue about transgender in the topic of human growth and development . . . . The pro and cons within the society about transgender were very interesting for the students that their discussion was very intense, many students express their opinions and positions regarding the issue.*" Concerning problem solving and critical thinking another teacher explained in the interview: "*For example, on the topic of environmental pollution, in this case, water pollution, as our school is located near a river polluted by waste such as plastic, I ask the students to propose ideas how to solve the problem. Some students thought of making the plastic waste into fuel . . . I also ask the students to reflect their daily activities which might contribute to river pollution, so that they can critically think of their habits and enhance their awareness to protect their environment.*"

Aside from considering the skills that can be enhanced by learning about SSIs among the students, the teachers also considered some competencies that can potentially help the teachers themselves. These competencies tended to fall into seven categories: designing innovative contextual learning,

developing teaching skills, acquiring interdisciplinary knowledge, utilizing varied learning sources, making authentic assessments, motivating students, and developing critical thinking skills (Table 3).

Table 3. Teacher competencies developed during SSI-based learning (% = teachers mentioning).

No.	Category	Description	%
1.	Designing innovative contextualized learning	Any response related to integrating daily life contexts to design and develop innovative science teaching	45.5
2.	Teaching skills	Any response related to teaching skills, including the ability to organize classes, manage time, etc.	24.2
3.	Interdisciplinary knowledge	Any response related to enhancing interdisciplinary knowledge, getting up-to-date information, etc.	12.1
4.	Utilizing varied learning sources	Any response related to organizing, utilizing, designing, or developing various learning sources	11.1
5.	Making authentic assessment	Any response regarding comprehensive assessments that cover all dimensions of learning	8.1
6.	Motivating students	Any response related to teachers' ability to motivate students to be more engaged in learning	8.1
7.	Critical thinking	Any response related to critical or reflexive thinking	7.1

Nearly half of the teachers considered that SSI-based teaching might enhance the teachers' ability in designing innovative contextual teaching, as also suggested in the interviews: "*Teachers would be more skillful in designing contextual learning based on specific problems which occur in their environment.*" The teachers also suggest that SSI-based science education can enhance their teaching skills: "*Teachers will be better at managing the class so that within the limited amount of time provided, the class can cover the material suggested by the curriculum. They can also educate their students to take care of and think about their societal problems.*"

Most teachers expressed positive views on the contribution of SSI-based learning on student character formation (Figure 4).
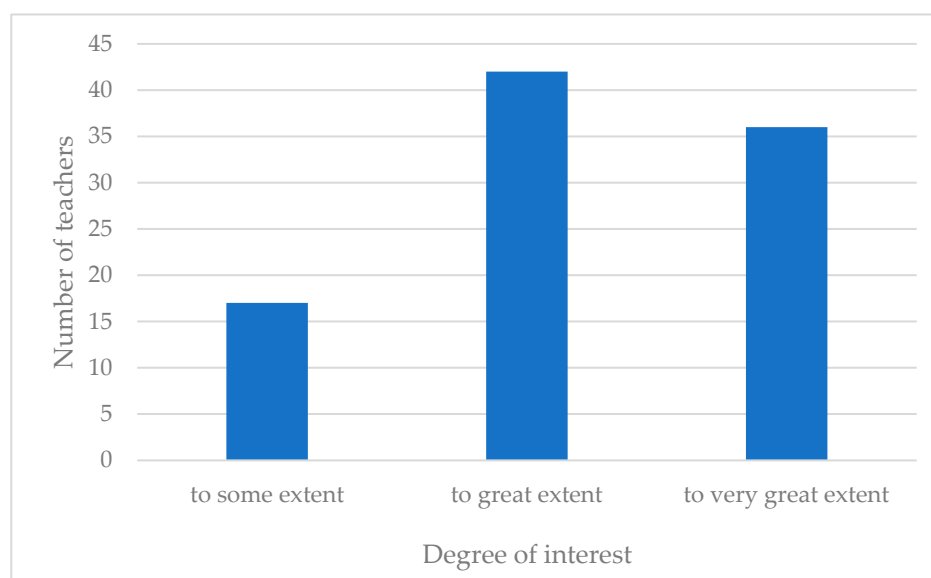

Figure 4. Science teachers' perceptions as to what extent SSI-based learning can contribute to character formation.

The aspects of character formation, which may be potentially supported by SSI-based learning, could be placed in seven categories. Environmental and social awareness were the two primary character traits prominently perceived as fruitful by the teachers for SSI-based learning. Other character

aspects frequently mentioned were open-mindedness/respectfulness, responsibility, collaboration skills, critical thinking, positive attitudes, and consideration of values (Table 4).

Table 4. Character aspects that might be developed by SSI-based pedagogies.

No.	Category	Description	%
1.	Environmental and social awareness	Any response related to awareness of the environment, nature or society	34.3
2.	Open-mindedness/ respectfulness	Any response related to being open-minded and respecting other individuals or groups	15.2
3.	Responsibility	Any response related to decision-making or taking action in a responsible manner	12.1
4.	Collaboration	Any response related to working together or collaboration	11.1
5.	Critical thinking	Any response related to critical or reflexive thinking	9.1
6.	Good attitudes	Any response that shows implementation of positive attitudes in a general sense	9.1
7.	Considering values	Any response related to considering values, such as religious or cultural beliefs, ethical considerations, norms	6.1

The aspect of students' character formation that most of the teachers addressed, also in the interviews, to be potentially developed was environmental and social awareness: "*The students might be more aware about the issues in their environment or society, issues which are neglected.*" The second often mentioned aspect of character formation was open-mindedness: "*Students have different opinions and are respectful to diversity. They might become open to different perspectives. Learners can communicate their opinions politely, based on evidence.*"

Out of 33 science topics found in the Indonesian junior secondary school curriculum, some topics were seen as having potential for implementing SSI-based learning. Eleven potential topics were each suggested by more than 40% of the teachers. These topics commonly deal with the environment or technology (Table 5).

Table 5. The potential topics for SSI-based learning.

No.	Topic	%
1.	Environmental pollution	87.9
2.	Food biotechnology	81.8
3.	Global warming	77.8
4.	Addictive substances and additives	74.8
5.	Green technology	73.7
6.	Civilization and environment	50.5
7.	Interaction of living things and the environment	47.5
8.	Heredity	43.4
9.	Soil and life sustainability	43.4
10.	Energy and life systems	41.4
11.	The human reproductive system	41.4

The teachers, however, also described several challenges hindering them from implementing SSI-based education effectively. The responses were grouped into five categories, namely: lack of students' competencies, lack of teacher expertise, content in the curriculum, lack of facilities, and lack of time (Table 6).

Table 6. Challenge in implementing SSI-based learning (% = teachers mentioning).

No.	Category	Description	%
1.	Lack of student competencies	Any response related to students' lack of abilities/competencies/skills	32.3
2.	Lack of teachers' expertise	Any response related to the teacher's lack of knowledge, experience, and expertise	26.3
3.	Content in the curriculum	Any response related to the nature of the content in the curriculum or emphasis on teaching the content	25.3
4.	Lack of facilities	Any response related to facilities, including missing learning resources, or media	17.2
5.	Lack of time	Any response related to limited time	13.1

Lack of students' competencies is the most often suggested challenge in implementing SSI-based instruction, as also mentioned in the interviews: "*Most of my students are lower achieving students. It is difficult to engage my students in an active discussion. I have to make sure that they understand the science concept before involving them in the discussion about a societal issue like that.*" Another point the teachers stressed about the students' reading abilities: "*I think this approach requires the students to read a lot of sources in order to understand the problem, but my students are not motivated and very poor in reading comprehension.*"

Despite all the possible challenges to implementing SSI-based instruction, most of the teachers were interested in implementing SSIs in their teaching practice, at least to some extent (Figure 5).
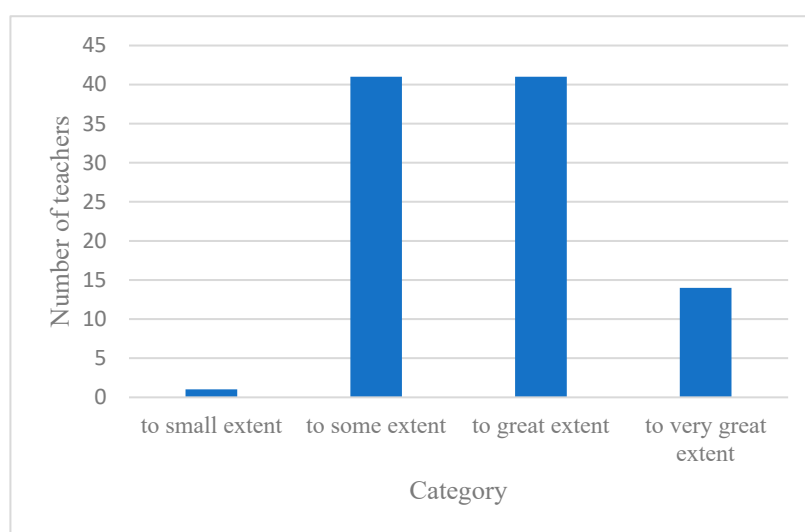

Figure 5. Science teachers' perceptions as to what extent they are interested in implementing SSI-based pedagogy.

From the interview, we also can see that many teachers were interested in implementing SSI-based teaching because they see a chance to enhance the relevance of science education, as well as to promote students competencies: "*I think I am interested to use SSIs in class because these issues are very relevant to students' lives. They can challenge students to be creative in solving problems from within the society.*" Some teachers, however, were indifferent because this would be a new approach to teaching science to them. When asked in the interview about why they were interested in only some extent, one said: "*I think it is an interesting approach but I am not pretty sure how to use the SSIs in my class.*" This quote supports the factor that hinders teachers to implement SSI-based learning, that is the teachers' lack of knowledge, experience, and expertise regarding the SSI-approach.

4. Discussion

It is likely that SSI-based pedagogies are known by only about half of the junior secondary science teachers from this sample in Indonesia. Even among teachers familiar with SSI-based education, most of them do not regularly apply them in their lessons. SSIs have become a focal point of science teaching since the end of the 1990s [28], but they are probably better known in countries outside Indonesia. SSIs have represented an emerging field in science education research in Western countries over the last decade. Researchers have provided many theoretical and conceptual justifications for including SSI-based pedagogies to achieve scientific literacy as the goal of science education [7] and developed corresponding didactic models [14]. Nevertheless, the application of SSI-based approaches is still limited even in Western countries because the primary goal of science instruction is still seen by many teachers as delivering science facts and theories [7]. In Indonesia, the SSI-based approach seems to have not been developed extensively and has had only limited influence on curriculum reform in science education [12].

The participants in the study acknowledged many competencies and skills that can be developed using SSI-based teaching and learning. This was believed to be true for both students and teachers. Using the framework outlined by Holbrook and Rannikmae, who proposed three domains of science education for enhancing scientific literacy [29], the skills suggested by the teachers covered the individual, societal, and nature of science domains. The individual domain includes aspects such as communication, critical thinking, literacy (in terms of reading competence), creativity, and higher-order thinking skills. Skills such as solving societal problems, social and environmental awareness, scientific literacy (in terms of applying knowledge for socio-scientific decision-making), interlinking science–technology–society, and collaboration could be linked to the societal domain. The nature of the science domain was also referred to in terms of scientific inquiry.

The teachers acknowledged the relatedness of SSIs to their students' lives and to society. They viewed SSIs as a way to help students, including lower-achieving students, become more involved in discussions, which can increase communication skills. SSI-based learning has previously been described in the literature as an enhancement of students' communication skills, such as the ability to relate ideas, to take stances, to be prepared for discussion, and to communicate a position [30]. It has also been suggested that SSIs can enhance levels of personal engagement and foster a greater sense of relevance among students [1,31]. There is hope that such teaching approaches can have a positive impact on students' interest because learners tend to be curious about SSIs in order to gain more knowledge about a given subject [32]. The teachers also recognized potential for enhancing collaborative and problem-solving skills. SSI-based approaches were suggested as a way to offer students further chances to engage in higher-order cognitive practices, such as argumentation, reasoning, and decision-making [33]. In this study, only a few of the teachers acknowledged the latter aspects, perhaps due to their limited personal experience. In the literature, it has been previously suggested that teachers should teach and actively practice higher-order thinking skills with their students if they want to develop them in their learners [34].

The participants also recognized several teacher competencies that might be developed, if educators use SSIs. Most of these abilities revolved around professional pedagogical skills, such as designing contextualized learning, utilizing and developing various learning materials, developing teaching skills, making authentic assessments, and motivating students. Teachers saw SSI-based instruction as a potential tool for designing contextual learning by integrating daily life contexts into lessons. They also stated that SSIs can be used to develop learning materials that are context-based and closely related to their students' personal needs. The teachers in this study suggested that SSIs can offer chances for more authentic teaching practices and assessments. This not only addresses the area of the assessment of knowledge but also includes the development of attitudes and other skills, including higher-order thinking skills. SSI-based teaching requires a broader, more highly integrated knowledge base borrowed from various disciplines. If teachers want their students to become critical thinkers, they need to practice such skills themselves.

The participants also believed that SSI-based education can positively contribute to character formation. Societal and environmental awareness are the aspects of character formation that were given the highest priority in this study. This falls in line with the literature, suggesting that ethical awareness and sensitivity can indeed be enhanced by SSI-based education [35–37]. Further aspects of character formation concerned open-mindedness and respect (see also [19,35]).

Constructing and delivering SSI-based education is a challenging undertaking by its very nature [38]. In our study, many teachers were skeptical of their students' abilities to participate in SSI-based discussions. They consider SSI-based education to be a big challenge. They suggested an overall lack of student competency in areas such as cognitive and reading skills. Many teachers listed this and other factors quite frequently when being asked about potential hinderances to SSI implementation. Analyzing PISA test results, Cromley found a high level of correlation between students' reading comprehension skills and their science proficiency [39]. PISA results since 2003 have shown that Indonesian students' performance in reading and science has consistently been below the average calculated for Organization for Economic Cooperation and Development (OECD) countries [40–44]. This means that implementing complex SSIs in Indonesian science education may be more difficult than in other countries.

Some participants also addressed personal limitations in their own knowledge, experience, and expertise when it comes to SSI-based teaching. They felt that they do not have sufficient time and expertise in creating material for innovative instruction, as previously also reported by Fogleman et al. [45]. Another challenge suggested by many of the teachers was the lack of facilities to support SSI-based instruction, including Internet access. The students are not allowed to use a mobile phone during the lesson so that the students cannot access the Internet. Presley et al. or Marks and Eilks [14,33] recommend using authentic media offerings to establish a classroom connection to the real world. They argued that teachers and students can use digital communication technology in order to access many forms of media such as newspaper content, videos, Internet pages, etc. Moreover, students' personal perception of the relevance of science education might be enhanced by the use of authentic media [46]. This is, however, difficult if access to digital media and the Internet in schools is limited.

The teachers in this study also viewed the nature of science content in the curriculum as a challenging factor when trying to implement SSI-based instruction. Most of the teachers felt obliged to concentrate on delivering condensed science content in order to prepare their students for final exams. This is in line with the findings reported by Subiantoro [12]. Moreover, in the teachers' opinion, SSI-approaches require inordinately large quantities of time, both in lesson preparation and in carrying out lesson plans. One of the teachers, who had worked with transgender issues in the topic of human growth, stated that the students were very excited about the controversies regarding the societal aspects of this issue. She, however, also reported that their intense discussions had to be limited in class due to time constraints. Similar perception regarding limited time was also acknowledged by Korean science teachers [23].

Although the teachers perceived SSI-based education positively and saw its potential for character formation, the participants did not exhibit correspondingly high levels of implementation of SSI-based education in their classrooms. It is suggested that teachers must be given more resources and be provided with thorough support in order to overcome any difficulties encountered in implementing SSI-based learning [38,47]. Such support needs to be provided by policy makers, curriculum developers, and science education research so that teachers can overcome any problems they face in implementing SSI-based pedagogies at the classroom level. This should result in developing SSI-based teaching and learning materials and corresponding media. The development could start with advantageous topics such as environmental pollution, food biotechnology, or global warming, which easily lend themselves to SSI-focused efforts.

5. Conclusions

About half of the teachers in the current sample were familiar with SSI-based learning, at least to a certain extent. Regardless of their missing theoretical knowledge, however, some of the other teachers had implemented SSIs to varying degrees in their classrooms, although not on a regular basis. Since many of them perceived SSI-based teaching and learning as a promising field, the situation might be bettered if any associated barriers could be overcome. The main barriers suggested by the participants concerned limits in students' skills, a lack of teachers' knowledge and expertise, the prevalent curriculum, lack of facilities, and time constraints. The best thing science education research and development can offer to overcome these obstacles is an investment in designing SSI-focused science learning sources and a commitment to continuous professional development concerning their usage.

6. Limitations

This study has several limitations. It only focuses on the Indonesian context and is merely a general survey. It nevertheless allows some practical insights into the practices and views of Indonesian teachers when it comes to implementing SSI-based instruction. The current study suggests that further research and action is needed to develop and evaluate practices of implementing SSIs in Indonesian science education. It also indicates that researchers need to explore exactly how teachers can develop expertise and experience with the aid of associated professional development.

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