The importance socio-scientific issues of in biology learning preparing students as a 21st century society

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Abstract. The purpose of 21st Century Education is to prepare students as societies by empowerment high order thinking skills, such as constructs arguments and decision making based on the evidence of Socio-scientific Issues (SSI). However, most teachers have limited experience in teaching SSI in their classes. Research learning through SSI to help limited experience in the teaching SSI has grown in various countries by raising issues related to learning materials in the society case. Literature review studies about SSI in biology learning research are needed to provide recommendation SSI approach in biology learning for preparing students in 21st Century societies.

1. Introduction
The ability to adapt to the challenges of the 21st century is crucial through the development of student skills, including initiative thinking, cooperation, working in a group, peer training, reasoning, problem-solving, obtaining and using information, planning, leaning skill, affective skill, dan multicultural skill [1]. The 21st-century skills are very various, so the focus of this study discusses the essential skills are required in 21st-century society according to Carlgren (2013) need developing communication, critical thinking (including argumentation, analysis, decision-making), and problem-solving in global society [2]. Reform teaching and learning by engage students in a community to negotiate, refine ideas, and develop ways of thinking in everyday lives issues to facilitation student as an active society [3]. SSI had a potential aspect to foster citizenship education through science education because the SSI are associate and bridge students lived experience and science education to prepare the student as a society in 21st century related within science, technology, and society (STS) in daily lives of citizens [4–9].

Socioscientific issues (SSI) are based on the controversial issue and part of science and social content including products and processes of science [5–7]. The importance of SSI is served as a useful and innovative context for learning and teaching science content knowledge [8]. A lot of science classroom are missing activities to engage students to focus on a social issue in society that requires scientific knowledge for provided decision making about the issue [4]. Science teachers said that teaching socioscientific is not easy and difficult for assessing student performance, teachers prefer to assess content knowledge in their subject learning, so the policy maker of education curriculum Sweden...
Science suggest those science teachers had to assess of argumentation skills, decision-making competence, the use of value for students according to the challenge of the 21st century through socioscientific learning [5]. The objectives of this study are to identify and compare the research studies on socioscientific issues (SSI) conducted in Indonesia and internationally of biology learning for preparing students to be an active twenty first century society.

2. Method
A literature reviewed is needed to provide recommendations of innovative socio-scientific issues (SSI) in Indonesian's biology learning to prepare students for the challenges of the 21st century. The result of literature review presenting on tabulation data including information of authors, title, year published, research, methods, sample size, content and result. This research also analysis SSI research education in Indonesia. The literature research is followed up with semistructured interview [6]. Semistructured interview conducts based on the result of literature review related the importance of SSI in biology learning and the sample is 14 graduated students in biology education master program who will conduct research to develop the quality of education.

Table 1. Semistructured interview.

| No | Author, Year, Location | Method | Sample Size | Content and Result |
|----|------------------------|--------|-------------|-------------------|
| 1  | Vaille Maree Dawson & Grady Venville, 2008, middle class suburb of Perth, Western Australia [7] | instrumental case study approach | 960 Students, Grade 8-12 | Teachers were taught two socioscientific issues such as genetically modified tomato (The Flavr Savr Tomato) and genetic testing for cystic fibrosis using argumentation lessons strategies. The result of this research is students quality of argumentation using Toulmin argument tool improved more than students who were not taught argumentation lessons strategies. |
| 2  | Troy D. Sadler and Vaille Dawson, 2011, University of Missouri Science Education Center, Science and Mathematics Education Centre, Curtin University [8] | research reviewed | No treatment | This study about implementation of SSI in science education and had conclusions that SSI can improve learning outcomes, science content knowledge, NOS, learning motivation, and argumentation skills. |
| No | Author, Year, Location | Methode | Sample Size | Content and Result |
|----|------------------------|---------|-------------|--------------------|
| 3  | Troy D. Sadler, William L. Romine & Mustafa Sami Topçu, 2016 Florida state science [9] | Eksperimen | 32 students | This study examine the effectiveness of using SSI based instruction in high school on molecular biology and genetic issues. Positive results are shown from the application of SSI context in understanding the useful of biotechnology tools to identifying various diseases through genetic engineering process. |
| 4  | Troy D. Sadler, Jaimie A. Foulk, Patricia J. Friedrichsen, 2017. University of Missouri-Columbia | design based research projects | No treatment | This study provide socio-scientific teaching and learning (SSI-TL). SSI-TL model has a syntax with the following stages 1)engganging student in science practice, 2) disciplinary core ideas and crosscutting concept, 3) synthesizing key ideas and practices. |
| 5  | Kimberly A. Walker & Dana L. Zeidler, 2007, South Florida [10] | case study | 36 students | WISE web-based activity is used for learning GMO food and students did role play as a consumer, scientist, EPA representative, genetic engineer, farmer, CEO of GMF producer. The result of using SSI approach can foster NOS concept and apply NOS concept in decision making about GMO foods. |
| 6  | H Lee, J. Yoo, K. Choia, Sung-Won Kima, J. Krajcik, Benjamin C. Hermanc and Dana L. Zeidler, 2014, South Korea [11] | Mixed method approach | 132 students | SSI approach is used in GM food content. The result of this study is SSI can develop communication skills of students and students more aware of the importance of morals, values, and character as global citizens because SSI genetics is indispensable in the future. |
| 7  | Yu Chen* and Winnie Wing Mui So, 2017, China [12] | Survey | 59 high school biology teachers | Using three SSI, such as genetic modification, gen therapy, and assisted reproductivetotechnology. SSI can be develop biology teachers in ethical reasoning skills to be confident in SSI and ethics in their classes. |
| 8  | Engin Karahan and Gillian Roehrig, 2016, USA [13] | Case study | 12 students of secondary school | Using SSI environment issue around the Minnesota River Basin, addressed to sedimentation and chemicals going into river Basin because of bad habit farmers in agricultural practices. SSI can contruc Socioscientific reasoning students |
| 9  | Florian Böttcher & Anke Meisert, 2011, Germany [14] | Quantitative | 202 student of 11th grade in high schools | Using Genetically modified in maize case for SSI to fostering decision making |
| 10 | Chi-Chin Chin, Wei-Cheng, Hsiao-Lin Tuan, 2014, Central Taiwan [15] | Mixed-methods | 28 students of elementary school | Using Socioscientific context climate change issues through arguing learning. The result this study dhowed that learning arguing about SSI global climate change had significant effect in teaching learning to develop literacy practice by combining reading and writing abou the SSI. |
Table 2. Cont.

| No | Author, Year, Location | Method | Sample Size | Content and Result |
|----|------------------------|--------|-------------|--------------------|
| 11 | Carl-Johan Rundgren, Martin Eriksson, and Shu-Nu Chang Rundgren, 2016, Sweden [16] | Qualitative method | Seven students of upper secondary school | This study used Sosioscientific Instructional module of environmental toxins in fish from the baltic sea to develop the argumentation skills of students. The result students can build arguments in different way and develop a meta awareness and value of the multidisciplinary factor that causes the issues. |

Table 3. SSI Research studies in Indonesia.

| No | Author, Year | Method | Sample | Focus Study | SSI Content |
|----|--------------|--------|--------|-------------|-------------|
| 1  | Anisa, Widodo, Riandi 2017 [17] | Case study | 41 students of high school and 13 postgraduate students | Argumentation | Genetic learning using cancer issues that uncontrolled cell division and proliferation. |
| 2  | Herawati, Ardianto | Qualitative | 28 preservise science teacher and 28 preservice non science teachers | Argumentation using Toulmin argumentation pattern (TAP) | Golden rice as Genetically Modified Organisms (GMOs) issues. |
| 3  | Wilsa, Mulyani, Susilowati, 2017 [18] | Quasi experiment | 2 classes of X grade high school student | Critical thinking Skills, Written and verbal communication | Diversity of organism. |
| 4  | Subiantoro, Paidi, Ariyanti, 2011 [19] | Lesson Study | Preservise teacher In chemistry education | Problem Based Learning with Socio-Scientific Issue for develop Character building | Inheritance of rambut gimbal in Wonosobo Dieng; Blooming of Caterpilar population; Effect of Cigarratte in Human health. |
| 5  | Widhy, Nurohman, Wibowo, 2013 [20] | Research and Development (R&D) | 30 student of junior school in yogyakarta | integrated science based socio scientific issues model for developing thinking skills | The eruption of Mount Merapi, additives in food, waste management, industrial waste from processing silver |
| 6  | Herlanti, 2014 [21] | Survey | 140 Undergraduated Students in UIN Jakarta | Argumentation Skills | Genetic Organism |
| 7  | Permanasari, Rostikawati, 2016 [22] | R&D method | VIII grade of junior high school | Scientific literacy | additives food |
| 8  | Aisya, Wibowo, Aminatun, 2016 [23] | Quasi eksperimental design | 2 classes of X grade High School | Reflective judgment | Ecosystem topic in disruption of the absorption process in the hydrological cycle because of hotel and mall expansion in the Yogyakarta |
Table 3. Cont.

| No | Author, Year | Method               | Sample                   | Focus Study             | SSI Content                                      |
|----|--------------|----------------------|--------------------------|-------------------------|--------------------------------------------------|
| 9  | Herlanti, Rustaman, Rohman, Fitriani, 2012 [24] | Qualitatif            | 29 undergraduated students | Argumentation Skills    | contamination of *E. sakazakii* in formula         |
| 10 | Rahayu, Meyliana, Arlingga, Reny, Siahaan, and Hernani, 2017 [25] | Research and development | 33 students of Junior high school. | Decision-making | Air pollution, water pollution, and soil pollution |
| 11 | Rizal, Siahaan, and Yuliani, 2017 [26] | Quantitative          | 34 students of VII grade | Decision Making         | Environmental Pollution                           |

3.1. The result of semistructured interviewed

All of students are interviewd agreed that SSI importance for developing 21 first century skill and agree that SSI can help to prepare students as a active society. However, the interviwed result showed fact that all students have never been learning biology by SSI Learning. This impact is all of graduate students do not know how to apply teaching and learning by SSI. The sample of manuscript semi structured interview:

*Students 1*: “I think SSI are very importance, raises many issues in our daily life. We must know about SSI for fostering 21 st century skill by decision making and critical thinking in genetic testing subject and I think we need something like module or book for application SSI”.

*Student 2*: SSI is very important because it raises issues that occur in the community and is directly related to biology learning, so SSI can develop students argumentation and decision making skill.

3.2. Selected SSI content

The topic of SSI had been selected on literature review discusses about genetic modified organism, environmental pollution, and climate change. Most of the SSI study studies that have been reviewed discuss GMOs. 18 % students selected ecosystem topic for SSI learning and supported argument “Indonesia has a diversity and uniqueness of ecosystem that is very abundant and has a high level of endemity, but the last fifteen years appear the reporting of the deforestation, the destruction of coral reefs and land clearing for oil palm plantations was raised as the case of SSI [27]. 36% students argued that rasing SSI topics of environmental pollution, and expressed worries about plastic waste and LIPI argued that “Indonesian rivers have been damaged due to pollutants like as the Ciliwung Rivers and Cisadane Rivers and their impact pollution on their river biota” [27].

The next importance topic of SSI is the application of genetic technology is one of the topics of SSI growing in the science community [12], so 18% students choosed genetic testing for prevent babies born with genetic disease, 18 % students SSI in biotechnology, and 9% selected genetic cloning for genetic modified organism. The results of the review literature also present interesting content about SSI in Indonesia is by using local socioculture issue such as inheritance of dreadlocks children phenomena in Dieng Plateu who are called “Anak Gembel”.

SSI is construct through raising cases of controversy in society by involving science content and social content. Understanding SSI topics is very crucial in developing life skills of global society students because of 1) Understanding SSI in the cases of health improves students' knowledge of health awareness 2) Understanding SSI topics in biodiversity is important in fostering conservation values to
maintain the abundance of biodiversity in Indonesia from the threat of deforestation, hunting endangered species and land clearing for agriculture [28].

3.3. Teaching SSI in biology learning
SSI is used as instructional contexts in science education including Biology, Physics, and Chemistry [29, 30]. All of the students didn’t know how to application SSI in teaching and learning. Based on the results of literature studies most SSI research globally using SSI framework in the learning process. SSI framework has core characteristics: 1) construction guidance around the issue 2) presenting the issue 3) engage student in higher order practices such as argumentation, reasoning, and decision making and 4) provide experience [31]. SSI learning uses a variety of learning strategies including simulations, discussion, role plays, oral presentation, jigsaw discussion, forum, conference, debate, and written reports or it can use conventional science classroom as a laboratory practice and guided inquiry [32]. As an example of conducted SSI learning strategies in the topic of GM food, students are engaged in role plays situation as consumer, scientist, EPA representative, genetic engineer, farmer, CEO of GMF producer [10]. While the application of SSI in Indonesia, some studies using Problem-Based Learning (PBL) model to teach the content of SSI [18, 33]. So, SSI could use various approaches, models, and learning and teaching strategies can be applied in SSI.

3.4. Benefits of SSI learning preparing student in 21 century
Competencies that must be proficient for Indonesia students to prepare them as twenty-first century society is creative thingking, critical thingking, communication, collaboration, Information, media and technology skills, character building, and spiritual value [34]. Based on this literature study can show that SSI in biology learning has great potential in developing life skills the 21st Century. There are the benefits of SSI is used to develop a skill thinking with the skill of arguing [5, 8, 15, 17, 24, 35] by used Toulmin Argument Pattern (TAP); SSI also develops students’ ability to make decisions about socio-scientific issues [14, 25]; SSI builds socioscientific reasoning skills [12, 13]; and increase the science literacy of students [22, 33, 36].

Based on the usefulness of SSI in biology learning, SSI can be recommended to be applied in Secondary School, High School, or in higher education. Graduated student can develop module, book, or model for teaching and learning SSI for future research to encourage 21st century skills.

4. Conclusion
The socioscientific issue provides useful contexts for teaching and learning biology content. The Features of SSI based approach is importance for developing twenty-first century skill. We published this paper as an initial research for investigating the importance of biology learning can cover the feature of SSI based approach and presenting this study as a reference for studies SSI in future.

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