**School of Education**

# Promoting Socio-scientific Issues-based Learning in Biology: Indonesian Students' and Teacher's Perceptions and Students' Informal Reasoning

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## DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature : 

Date : 30/11/2016.

# Abstract

This research was conducted to examine the outcomes of promoting socio-scientific issues (SSIs)-based instruction in secondary school biology classrooms in Indonesia. To attain its purpose, four research questions led this research in regard to knowing: whether a development of an instrument for assessing students' perceptions of SSI-based instruction can produce a reliable and valid instrument, how Indonesian students' perceive of SSIs-based learning in biology, what type of informal reasoning that can be performed by students in SSIs-based learning, and Indonesian biology teachers' perceptions of SSIs teaching practice.

As this research is attempting to develop and implement an innovation (i.e SSIs-based instruction) in the context of Indonesia, this research is carried out as a case study design. Based on research questions, two phases of research were implemented. The first phase was conducted in dealing with research question one, and the second phase was for the remaining three research questions.

For the first research question, this study utilised both qualitative and quantitative approaches within three stages. The first stage was analysis and construction of the items for the defined scales including contextualisation of SSIs, attitude toward SSIs-learning, student involvement, and SSI-learning objective. Following the first stage, the proposed items constructed were reviewed and validated for substantial statements as well as language conformity. The 28-developed items of the questionnaire in Bahasa Indonesia then were administered to 284 grade 10 and 11 students of senior high schools in Central Java, Indonesia. Data from the administration were analysed using factor analysis with varimax rotation. Based on the factor loading results, four items were removed because they were not loaded on one factor. Thus, the 24 remaining items supported the four-scale structure suggesting that the questionnaire has statistical validity. Moreover, the Cronbach alpha coefficient for each scale was calculated above 0.70 which indicates that they have internal consistency reliability.

Following the first phase, four biology teachers with various teaching experiences were involved in phase two of this research. They are from different secondary

schools in Indonesia and voluntarily participated in this research. In this phase, a "case" is defined as a SSIs-based instruction which was designed and introduced through a teacher professional learning program, and then implemented by each teacher in his/her biology classroom. The teacher professional learning program was conducted in four stages, including: 1) reflection of teaching experiences and background knowledge, 2) workshops on SSIs-based teaching, 3) the development and implementation of SSIs-based learning materials in biology classrooms, and 4) reflection of post-implementation. Hence, both students' as well as teachers' perception of SSI-based instruction were assessed throughout these stages.

Using reflection sheets, personal journals, observations and interviews, data about teachers' perceptions of SSI-teaching practice were collected. On the other side, students' perceptions of SSI-based learning data were collected through the developed questionnaire, observations, and interviews at before, during and after the implementation of SSI-lesson (i.e stage #3 of the above-mentioned program). In particular, data about students' informal reasoning skills were collected with informal reasoning assignment sheets at before and after SSI-lesson.

Given the data that have been obtained, data analysis was carried out with two approaches. First, an explanation-building mode was used as the basic analytic method for this research which seeks to explain the investigated phenomena by the unit of analysis. The unit of analysis of this case study is "the class" of students for each aspect that encompasses: 1) students' perceptions of SSIs-based learning, 2) students' informal reasoning, and 3) teachers' perceptions of SSIs-based teaching. Following this approach, cross-case analysis was applied to further examine the data across the cases and gain a deeper insight and understanding of the results. Specifically for informal reasoning skills, a basic framework of analysis is used which categorise the informal reasoning skills either as a single pattern of intuitive, emotive or rationalistic, or as an integrated pattern.

Regarding the second research question that is about students' perceptions of SSI-based learning, the data showed that Indonesian students who participated in this research perceived SSI-based learning as a new way of learning that provided a useful vehicle for students to find a socially-emphasised contextualisation of their

biology lessons. The participants also perceived that SSI-lessons provide a positive atmosphere which has a great impact for their involvement. Moreover, responding to the issues from multiple perspectives, generated an insightful view of the issues, related-values of science and technology considerations, and communication skills, perceived by students as learning objectives which they could obtain in their SSI-learning. Lastly, three main dimensions of attitudes toward SSI-lesson were perceived by students, including: students' role in the SSI-group activities, teachers' role in doing SSI-based teaching, and students' preference on SSI-learning strategies.

A key point that was reflected from the data about students' informal reasoning is that for every SSI-lesson, each of intuitive, emotive and rationalistic pattern of informal reasoning could be generated by students in responding the issue even before they experienced SSI-lesson. Furthermore, the data also showed the extent to which informal reasoning patterns that were initially expressed by students before participating in SSIs-lessons could be shifted to other pattern. Thus, these changes reflect the possibility of the adaptation of the argument perspectives or orientations during the SSIs-lesson and may contribute to students' thoughts for further decisions after the instruction.

To come to the last research question that is related to biology teachers' perceptions of SSI-teaching practice, the research findings show a lack of recognizable features of SSI perceived by Indonesian biology teachers who participated in this research. This fact is influenced by a lack of experience and basic knowledge on SSI-teaching practice before they participated in the teacher learning program. However, being induced on SSI-teaching knowledge makes teachers have a basic insight on the necessity of and factors that influence on SSI-teaching practice as well as encouraged to implement it in their biology classrooms. Experiencing SSI-teaching implementation deepened their conceptions about the advantages as well as challenges incorporated in SSI-teaching.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Overview

The aim of this study is mainly to investigate how socio-scientific issues (SSIs)-based learning in biology classrooms in Indonesia can contribute to scientific literacy and character orientation. This aim is further broken down into specific purposes including: to develop an instrument for exploring students' perceptions of SSIs-based learning, to investigate biology teachers' and students' perceptions regarding SSIs-based learning of biology, and to identify the types of informal reasoning that may be performed by students based on the SSIs-based teaching and learning.

This chapter starts with the background of the study in Section 1.2 which describes a story of how this research began and was based on the author's experiences. Section 1.3 provides a 'map' of the study in which the rationale leads to the background, on the one hand, and review of some basic literature on the other hand, each of which needs to be considered to address the main problems of the research. Thus, this main problem is represented in terms of the research questions in Section 1.4 that drive the research towards its purposes. Following the research questions, the significance of the study and the overview of the thesis are illustrated in Sections 1.5 and 1.6 respectively.

## 1.2 Background of the study: Development based on experience

In 2008, there was shocking-news that caused Indonesian people to be surprised and worried. Broadcasts on TV and also newspapers reported the results of a study carried out by a team from a well-known university in Indonesia which revealed that some brands of infant formula milk were infected with *Enterobacter sakazakii*.

The report also explained that the existing bacteria might cause a number of vital diseases in babies including meningitis or hydrocephalus. Yet, this news became controversial because many people discussed the news regarding the health risk that might impinge on babies, as well as why the products had escaped the quality control process and were freely marketed. Many citizens asked where was the government department that was responsible for regulating the industries that trade in the product? Other citizens were questioning the validity of the research.

Furthermore, the news also had led to a broad debate among mothers about the safety and importance of giving formula milk to their infants. Some of the mothers argued that, based on research, that breast feeding is the best intake for babies and it was not necessary to give them formula milk. On the other hand, other mothers suggested that there is no adequate evidence showing the relationship between bacteria in formula milk and the fatal death of babies. The second group of people thought that formula milk would make babies healthier and that it is really helpful for mothers who are unable to breast feed their babies.

Both the infected formula milk and debate about babies feeding made sense to me and I considered the issues were potentially useful for science education practice in Indonesia. Briefly viewed, these issues involved scientific concepts, particularly in biology such as the characteristics and the life of bacteria and breastfeeding as a part of the physiological process in women's bodies and relates to human development. These concepts are essential to be taught and are typically included in the biological curriculum for secondary school students in Indonesia. Besides scientific matters, each issue also provides a situation in which students may be engaged in a valuable activity for their learning, such as critical thinking, a debate or class discussion, toward resolving an issue. What I imagined was that bringing such an issue to class would be a meaningful learning process. Students could be invited to a real social-like setting in which they are expected to be aware about such problems in which science and social aspects might be related and, in turn, be a part of the community and that they would have responsibility to contribute to as well as share their ideas to deal with the problem.

That the potential of such science-related issues could challenge students to confront their scientific knowledge with social considerations led me to reflect upon my experience in my biology education practice in secondary schools in Indonesia. Since I became involved in the biology teacher education program in a state university and have been working with many biology teachers, I viewed that there were limited occasions where socially-contextualised problems were discussed in the biology classroom and this seemed to be an obstacle for curriculum goal attainment. For instance, probing and using relevant knowledge, evidence and information in order to solve daily life problems, as one of the goals of the biology curriculum, requires appropriate contexts by which the problems should be found and learnt by students in a set of learning experiences arranged by the teacher. However, instead of placing a real life problem as the central part of the lesson for engaging students to achieve those skills during instruction, frequently the problem just plays as 'an introductory part' of the lesson for providing the example of the topic. Then, learning is mostly oriented toward the science content and for the final examination rather than developing the expected skills. Generally stated, there is a discrepancy between the needs of accomplishing the curriculum goals and the instructional process that were carried out. What I can presume about this discrepancy is that there might not have been any studies provided nor examples afforded on how to design and apply an instructional activity that accommodates that need of appropriate contexts for biology teachers.

## 1.3 Find the map: Rationale for the research

Reflecting on the experience described above drove my interest and ideas toward the exploration and utilization of socially-based and science-related issues in science learning. This effort then brought me to one of the considerably advanced and growing themes in science education studies termed "socio-scientific issues" (SSIs). SSIs are open-ended problems that tend to promote multiple perspectives in which scientific concepts or procedural understandings must be considered within some social aspects that are held by individuals or groups of a community toward

different reasonable solutions (Sadler, 2011). SSIs, then, represent the conflicting views that emerged from the interrelationship between science and social aspects in society in which people may have distinct opinions based on their understanding of science as well as the values, ethical dimensions, and beliefs that influence them to negotiate an issue and enable them to make their own decisions (Zeidler & Keefer, 2003; Zeidler et al., 2005).

In recent years, the use of socio-scientific issues in school science learning has become a topic of great interest in science education research worldwide. Numerous studies on the implementation of SSIs have been conducted involving various topics to enable students to contextualize their world and enhance their participation in science learning (e.g., Feierabend & Eilks, 2010; Lenz & Willcox, 2012; Ottander & Ekborg, 2012) and develop scientific knowledge, higher order thinking and multi-perspective reasoning as well as argumentation and decision making in students (e.g., Chowning, Griswold, Kovarik, & Collins, 2012; Dawson & Venville, 2013; Sadler, Barab, & Scott, 2007; Venville & Dawson, 2010). Moreover, SSIs help to foster moral and ethical considerations among students toward scientific-based cases in their society (e.g Lundstrom, Ekborg, & Ideland, 2012).

These studies reflect a key point of implementing SSIs in science learning which relies on the function of SSIs as a context for attaining the goal of scientific literacy in science education as well as the practice of citizenship education (Sadler, 2009, 2011; Sadler et al., 2007). Scientific literacy may result based on appropriate understanding of science and the ability to make responsible decisions regarding science-related issues that arise in society (Dawson & Venville, 2009). The development of moral, ethical and value dimensions through SSIs enable student empowerment about these aspects in SSIs-based learning toward character education. In this way, students might become active and better citizens (Lee, 2012; Sadler, Klosterman, & Topcu, 2011; Zeidler & Nichols, 2009). Thus, this valuable feature of SSIs is relevant to the needs of biology instruction for supporting character education in Indonesia (Subiantoro, 2011). However, even though SSIs-based learning has been broadly implemented in science classes involving

thousands of students worldwide, to date this practice has not been extensively developed in Indonesia as only few research studies have been done in this area (e.g., Herlanti, Rustaman, Rohman, & Fitriani, 2012; Subiantoro, Ariyanti, & Sulistyo, 2013). Thus, SSI-based instruction could be seen as a new instructional approach in science education practice in Indonesia.

Promoting SSIs-based learning as a useful strategy for character education as well as for scientific literacy in biology education requires well-prepared biology teachers who can be encouraged to implement SSIs and be aware of their important role in biology teaching practice (Ekborg, Ottander, Silfver, & Simon, 2013; Forbes & Davis, 2008). Since SSIs-based instruction can be considered as a new instructional approach in the biology curriculum in Indonesia, a great effort to understand how biology teachers will perceive this innovation needs to be carried out. As van den Akker (1988) pointed out, the degree of effectiveness of an initial learning process associated with curriculum innovation is when teachers have experienced the 'spirit' of the programme in their 'role-taking' behaviour and know the what, when, how, and why of the innovation in their teaching role. Such experience provides them with clear advice about the implications of these matters for classroom practice.

Besides the intentions of the teachers' role in teaching SSIs as well as any strategies that have been developed (e.g., Ekborg et al., 2013; Gray & Bryce, 2006; Lee, 2007; Rudsberg, Ohman, & Ostman, 2013), understanding students' perceptions of the implementation of SSIs in their science learning can be viewed as an evaluation of the learning environment that they experience during the learning process in specific settings. Understanding the quality of the learning environment in which students and teachers are working together can help teachers improve their teaching practice as well as their students' achievement (Fraser, 2001). However, only a few studies have been conducted involving students' perceptions of their experiences in SSIs-based lessons (e.g., Eastwood, Schlegel, & Cook, 2011; Feierabend & Eilks, 2010; Ottander & Ekborg, 2012; Topcu, 2010).

Particularly regarding the instruments that were employed in the aforementioned studies, I argue that these were not entirely suitable for further research in secondary biology classrooms in Indonesia. For example, one of the instruments developed by Ottander and Ekborg (2012) explored in-depth students' experiences. However, as this instrument measures students' characteristics in general science learning instead of SSIs topics, it is assumed that students' perceptions were not directly associated with SSIs-based learning. On the other hand, the instrument used by Feierabend and Eilks (2010) required a further adaptation as it was developed for a specific subject (chemistry) instead of SSIs-based instruction in biology. The ATSIS seems also not suitable because it assesses only attitude towards SSIs rather than SSIs-based learning and was specifically developed for undergraduate students. Thus, to investigate students' perceptions of SSI-based learning in secondary biology classrooms first requires preliminary research on the development of a suitable instrument.

Besides perceptions, examining student achievement is also an important aspect in SSIs-based instruction that needs to be considered. Eastwood et al. (2011) points out it is important to understand how SSIs-based learning is designed, what students will experience and perceive, and what they will achieve in their learning. Regarding this consideration, one of the essential skills related to SSIs discourse is informal reasoning.

As SSIs represent social-related science problems that require multiple perspectives and fusion of scientific understanding as well as ethical consideration, the way an individual negotiates the issues may require different forms of reasoning compared to dealing with standard science problems. In this regard, unlike formal reasoning that ordinarily applies within the context of mathematics and symbolic logic, informal reasoning involves reasoning about causes and consequences, pros and cons, advantages and disadvantages, generation and evaluation of positions that underlie attitude and opinion in response to complex issues with no clear-cut solution (Sadler, 2004; Sadler & Zeidler, 2005; Zohar & Nemet, 2002). Therefore, informal reasoning is mainly used when reasons are needed to support or rebuke

the opinion and conclusion about what to believe or what actions to take (Wu & Tsai, 2007, 2011).

Research on informal reasoning is viewed as a well-defined area for contemporary study of SSIs-based science instruction. Indeed, study about the characteristics of informal reasoning performed by students also emerged as an important topic as Sadler and Zeidler (2005) point out that understanding the pattern of students' informal reasoning skills is strongly useful for reflecting the science learning experienced by students with respect to scientific literacy. The role of informal reasoning in the SSIs-based discourse represents a type of reasoning skills that are applied to the issues discussed. Otherwise, since informal reasoning is viewed as a unique skill in the negotiation of SSIs, it may also depict another learning dimension regarding factors that influence its expression. According to Topcu, Tuzun, and Sadler (2011), for instance, it was reported that personal experiences, the nature of science (NOS) conceptualization, moral perspective, and content knowledge, are factors that could influence learners' informal reasoning. Thus, it should be noted that these factors need to be considered in any attempt to design and implement SSIs-based learning innovation.

The reviews of the literature above, reshape and lead an initiative on promoting SSIs-based learning in Indonesia. Overall, as previously mentioned, since the utilisation of SSIs discourse in science education practice in an Indonesia context has been conducted in a very limited way to date, a fundamental issue in this research is on how SSIs-based instruction could be developed, implemented, and examined in science education practice, particularly in the biology classroom. Considered an essential attempt to introduce SSIs-based learning as an innovation in science education in Indonesia, this study can be viewed as ground-breaking in its field; the study emphasizes teachers' and students' perspectives, particularly about their perceptions of SSIs-based teaching and learning, and how students' informal reasoning is expressed regarding SSIs-based lessons.

## 1.4 Research Questions

The main purpose of this research is to promote SSIs-based learning in biology instruction for achieving the goal of scientific literacy in science education as well as supporting character education in Indonesia. Specifically, the purposes of this study are to develop an instrument for exploring students' perceptions of SSIs-based learning, investigate biology teachers' and students' perceptions about SSIs-based learning in biology and the type of informal reasoning that may be performed by students based on their SSIs-based learning. The research questions that lead to these purposes of research are:

(1) Do students' perceptions of SSIs-learning scales designed for assessing students' perceptions of SSIs-based learning produce a reliable and valid instrument?

(2) What are Indonesian students' perceptions of SSIs-based learning in biology?

(3) What types of informal reasoning can be performed by students in SSIs-based learning?

(4) What are Indonesian biology teachers' perceptions of SSIs teaching practice?

## 1.5 Significance of the study

This study is significant in several ways. Firstly, this study will provide an understanding of the possible advantages, weaknesses and problems that might arise when developing SSIs-based learning in biology education based on particular contexts in Indonesia. As it is considered that SSIs-based learning is an innovation in the science education landscape in Indonesia, this implication is useful as basic knowledge for the author as well as other science education researchers in Indonesia who have interest specifically in SSIs-education. This research attempts to build a conceptual and instructional framework for further research and practice in the field of study.

Secondly, this study will be crucial in contributing to the sustainability of professional development programs for in-service teachers as well as pre-service teachers. This study provides a model of teacher professional development programs on the development and implementation of SSIs-based learning in biology classrooms. However, it should be noted that this model is tentative, challenging and has to be adapted, modified, or even developed further in terms of the learning topics, the teaching strategy, and also the assessment approach as well as instruments. Furthermore, what can be expected based on this implication is a great opportunity for an advantage networking in which sharing the knowledge as well as research experience could be fostered between researcher, school communities and related academic institutions.

Lastly, in the broader context, this study will also provide empirical evidence for further research in SSIs-based learning. Following the previous implications, if researchers involved in SSIs teaching and learning could be diffused across regions and communities (particularly in Indonesia) and the advantages obtained for science education quality improvement, it has the potential to facilitate stakeholders or educational policy makers to review and reform the science education curriculum towards scientific literacy, character education, and be able to better compete globally.

## 1.6 Overview of the Thesis

The report of the research described in this thesis comprises eight chapters. Following this introduction, Chapter Two presents a review of the literature based on studies on the basic concept of socio-scientific issues (SSIs). The review of the literature incudes its relation to the role of contextualisation in science education practice, to scientific literacy orientation as the goal of science education practice particularly related to the Indonesian national curriculum, and how SSIs-based instruction has been developed by previous researchers. This chapter also describes science teachers' as well as students' experiences regarding their perceptions toward the implementation of SSIs-based teaching and learning. Especially for the

research question number one, which is related to the way this research examines students' perceptions of SSIs-based learning, a review of the literature about the development of the instrument is discussed. Informal reasoning, as an essential skill in SSIs learning, is also described in Chapter Two. The framework showing how this research is designed as well as methods used to collect and analyse the data are discussed in Chapter Three. Chapter Four discusses the development of the instrument, related to research question #1. Regarding research question #2 (students' perceptions of SSIs-learning), research question #3 (student informal reasoning skills), and research question #4 (teachers' perceptions of SSIs-teaching), each of the data and discussion is elaborated in Chapter Five, Six and Seven respectively. The last chapter, Chapter Eight, summarises the findings of each chapter by addressing the conclusions and critical limitations. Implications and recommendations for further research are also outlined in this last chapter.

# CHAPTER 2
# REVIEW OF LITERATURE

## 2.1 Overview

Generating a theoretical basis of the research requires a strong effort on defining and collecting relevance ideas as well as research findings which were previously conducted through a systematic literature review (Fraenkel and Wallen, 2009). This chapter provides a review of a number of literature in the field to drive this research study to address its research questions. Firstly, a review on SSI and the role of context in science education practice as well as how SSI can be viewed in the context of Indonesia are introduced and comprise section 2.2 namely, *Socio-scientific Issues in Science Education Research*. In section 2.3, the practical dimension of SSI-based instruction is explained within the sub-sections of the conceptual framework of SSI-based instruction, SSI-based lesson strategies and supported with a review on informal reasoning. As this research study is also aimed at investigating biology teachers' and students' experiences on SSI lesson, reviews about teacher professional learning and innovation in science education and science teachers' as well as students' experiences in SSI learning are provided in section 2.4. Lastly, the summary of the literature reviews and the way this research looks at the gaps within the literatures with its objectives are stated in section 2.5.

## 2.2 Socio-scientific Issues in Science Education Research

### *2.2.1 SSI and the role of contextualization in science education*

It is generally viewed by science education communities that the lack of motivation and interest in science teaching and learning experienced by many students is because of the overload of scientific content knowledge which mainly focuses on the science curriculum and targeted to be assessed in the final examination (e.g Albe et al., 2014; Ekborg, Ottander, Silfver, & Simon, 2013). Indeed, with the current

curriculum, it is likely to be difficult for students to make a connection between their science knowledge and relevant science-related problems in their everyday lives (Colucci-Gray & Fraser, 2012; Hofstein, Eilks, & Bybee, 2011; Marks & Eilks, 2009; Tytler, 2012). Hence, to achieve this connection, providing a relevant context is suggested as being a critical requirement that needs to be fulfilled in science teaching and learning. Sadler (2004) stated that contexts in science classroom are supposed to be formed by learners, including physical, conceptual, as well as considering the norms or values that potentially drive students to engage in science learning activities which can promote understanding, reflection and meaning-making of science knowledge. This view is strongly linked with the situated learning perspective (Sadler, 2009) which explains that a meaning-making process possibly occurs in learners' minds when there is no separation between what is being learnt and will be understood within the environment in which the issues or problems take place. It should be noted here that the meaning-making process is actually not only limited to gaining knowledge in an individual dimension but also how the knowledge is applied in the participatory activities in a social dimension by at least in two ways (der Zande, Akkerman, Brekelmans, Waarlo, & Vermunt, 2012). Firstly the approach of social practice becomes prescriptive and frames what is relevant to learn, and secondly, what is learnt by student takes place in relation to a situation that is related the practice.

Both the role of context as well as the situated learning perspective provides the same lens as context-based learning in giving a meaningful science learning experience for students. King and Ritchie (2012) asserted that context-based learning represents an approach in science education practice which attempts to make science learning more meaningful for students. Furthermore, besides the understanding of science concepts, the approach can also improve students' engagement as well as participation by providing social relevance of science knowledge in the classroom. This is an important task of science teaching and learning to make science more relevant and promote students ability to review what they learn in science from something which is fixed as a body of knowledge to be

a progressive way of understanding with considerations of contemporary social values (Osborne, MacPherson, Patterson, & Szu, 2012).

In an attempt to make learning meaningful, some studies pointed out the importance of the societal dimension as an essential component of science education practice to ensure scientific literacy (SL). In this context, SL implies that an individual student must develop the ability to critically evaluate and apply the information, make an appropriate decision, and also participate in a debate or discussion about science-related problems within a live environment (Arroio, 2010; Hofstein et al., 2011; Zeidler & Nichols, 2009; Zeidler, Sadler, Simmons, & Howes, 2005). Although there is a distinct interpretation on the meaning of SL that makes it ill-defined (Laugksch, 2000), however, Robert (2007) extensively offers two analytical categories to describe the *meaning* of SL as Vision I and Vision II. Whilst Vision I emphasises the thorough knowledgeability within science itself as process and product, or content of science, Vision II accentuates the knowledgeability "about science-related situation in which considerations other than science have an important place" (p. 730). Considering a rapid change of science and technology that may arise a various social-related science problems in society, the view of SL meaning needs to become broader in science education practice and "would need to encompass socio-scientific issues decision making beyond scientific problem-solving" (Holbrook and Rannikmae, 2009, p. 279).

Amongst the rapid developments of innovation in the science education field, socio-scientific issues (SSIs) have been of great interest in the contemporary research worldwide because SSIs provide useful contexts for science understanding in the frame of socio-cultural perspectives (Sadler & Dawson, 2012; Zeidler, 2013; Zeidler, Herman, Ruzek, Linder, & Lin, 2013). The features of SSIs are reviewed in relation to some issues used by a large number of studies in this field. For example, in a research that involved a 11th-grade science class in vocational secondary education, Albe (2008) challenged students to defend their arguments on whether mobile phones are dangerous, particularly of illness that might occur by mobile phone use in society. Based on a local and authentic context, for another

example, Lee and Grace (2010) used an issue about "bat intruders" where a colony of bats was using a small house in a village as a roosting site and the owner was annoyed and worried by the spread of disease transmitted by the bats. Resolving this issue, indeed, might imply a social-ethical consideration as well as bat conservation. Another issues such as nuclear power energy usage, genetic-related topics, health issues, or environment-related issues, have been documented by a number of research studies (Lederman, Antink, & Bartos, 2014; Lee, 2012). These studies showed SSI as controversial issues where scientific knowledge and social considerations are associated and present a cognitive conflict required to resolve the decision-making process such as "…the topics described by the phrase socio-scientific issues display a unique degree of societal interest, effect, and consequent" (Sadler, 2004, p. 513). Furthermore, SSI potentially meets societal needs of enhancing scientific literacy orientation in science education as it involves awareness toward science-technology-society relationships and allows students to be active participants in the decision-making process (Lee & Witz, 2009). Dealing with the role of SSI to contextualize a science topic, Zeidler and Nichols (2009) pointed out two considerations. Firstly, students generally tend not to think about the science topics that they have learnt unless those are relevant to them personally, thus, providing an issue which is personally or socially relevant to themselves would be useful in a learning process. Secondly, SSIs have the potential to challenge students to negotiate the issue from a humanistic perspective with moral and ethical considerations together with scientific knowledge to make an appropriate decision.

Although they have the same epistemological stand with the application of contexts as a fundamental base, there is a considerable distinction between Science-Technology-Society (STS) and SSI-based education as explained by Zeidler et al. (2005). Although the STS approach focuses on the impact of science and technology application on society, the authors pointed out that a basic problem is the absence of a coherent framework that explicitly considers embedded ethical issues as well as the development of character and values for students in science teaching and learning practice. Socio-scientific issue (SSI), on the other hand,

promotes its function to empower students with "the consideration of ethical issues and construction of moral judgement about scientific topic via social interaction and discourse" (Zeidler, et al, 2005, p. 360) and emphasizes the development of students' capabilities to deal with their world' problems (Sadler, 2004). Regarding these capabilities, a large number of studies have provided evidence about the role of SSIs implementation toward students' nature of science (NOS) understanding (e.g Eastwood et al., 2012; Lederman et al., 2014), science content knowledge (e.g Jho, Yoon, & Kim, 2014; Wu, 2013), reasoning skills, argumentations and decision-making (Bottcher & Meisert, 2013; Chowning, Griswold, Kovarik, & Collins, 2012; Dawson & Venville, 2013; Lee, 2007; Lee & Grace, 2012; Macagno & Konstantinidou, 2013; Papadouris, 2012; Patronis, Potari, & Spiliotopoulou, 1999), as well as scientific literacy (e.g Dawson & Venville, 2009). Supporting these studies are documented evidence on the function of SSI-based instruction practice for sustainability, awareness and education for sustainable development (e.g Gresch, Hasselhorn & Bogeholz, 2013; Tytler, 2012), attitude and character education in science (e.g Lee et al., 2013; Rundgren, 2011; Stenseth, Braten, & Stromso, 2016; Zeidler & Nichols, 2009), and epistemology consideration (e.g Morin, Tytler, Barraza, Simonneaux, & Simonneaux, 2013; Wu & Tsai, 2011).

### *2.2.2 SSI in the context of Indonesia*

To the best of my knowledge to date, there have been very limited number of research studies using SSIs that has been implemented in Indonesian context (e.g Herlanti, Rustaman, Rohman, & Fitriani, 2012; Subiantoro, Ariyanti, & Sulistyo, 2013). However, as it has been shown in the background of the research (Chapter #1), the development of SSIs-based education is strongly important for supporting character education as well as for achieving scientific literacy in science education practice in Indonesia. Nevertheless, identifying or defining potential issues that are relevant toward SSI-based learning in the context of Indonesia needs to be considered because Sadler (2004) explicitly recommends selecting local-based issues to provide a meaningful relevant context of science education in SSI-implementation. In respect to this localised-perspective, Robottom (2012) noted: 1)

the community is the main source of SSI-based learning program, 2) a carefully selected SSI-topics which are embedded in the cultural live of community can create a learning environment for the sustainability as well as cultural survival of the community, and 3) community knowledge along with epistemological beliefs held by members of the community play an important role in accommodating a social discourse in which individuals are able to weigh their views, ideas and the options of actions toward SSI resolution.

According to a previous study (Subiantoro, 2011), there are only a few local-based issues that can be potentially developed and implemented for SSI-based learning in Indonesia. Two main issues described included the dreadlocks-hair of Wonosobo people and the Merapi mountain eruption in Central Java, Indonesia. The first issue is based on the traditional shaving-ritual of the dreadlocks-hair in the Wonosobo society, Central Java, Indonesia. Dreadlocks-hair which naturally appears on children of the Wonosobo society basically represents a genetic phenomenon. However, instead of considering the fact in scientific perspectives, Wonosobo people address this phenomenon through a belief system that is represented by an indigenous shaving ritual containing spiritual, historical and philosophical values and involves traditional offerings, such as coins, rice, flowers and invocation.

In a different region of Central Java, one of the most active mountains in Indonesia, Merapi, plays an important role particularly on the ecosystem of the surrounding environment following an eruption. The last eruption which happened in 2010 led to huge damage on three sides of the mountain when hot volcanic material slid down about 15 km from the peak. The 1500$^{o}$C material caused great impact, such as destruction of forest, water resources and settlements as well as changing soil profiles. Moreover, the frozen lava induced shifting of land and river conditions. Besides water resources management and forest conservation, resident settlement is a crucial issue that arose as a result of the disaster. The National Volcanic Disaster Council recommended that there should be no settlement at least within a radius of 20 km from then peak, especially due to the pattern of Merapi eruption that commonly happens every four years. Consequently, the local government asked

people to move to safer areas. Unfortunately, not many people wanted to be relocated, believing that their life is only on or from Merapi and nothing could make them move to another region.

Those two issues present controversial problems that can be viewed within the SSI framework. For the dreadlocks-hair phenomenon, scientific evidence about trait inheritance of the hair seems to clash with the belief system hold by the Wonosobo society. Regardless of the relationship between coins, rice, flowers or invocation with the biological feature of dreadlocks, as a cultural identity the ritual encourages people to tightly maintain their belief. Similarly as aforementioned, traditional reasoning of dependency on nature held by people of Merapi is hard to understand based on the scientific perspective. On this point, it seems that there a conflict between scientific perspective, cultural belief and social consideration (particularly economics) that both communities might be faced with and, therefore, these instances can be viewed as socio-scientific issues. An Indonesia-context based issue was employed in research on uncontrolled collection of rattan in the Indonesian rainforest (Eggert, Ostermeyer, Hasselhorn, & Bogeholz, 2013). The research illustrated how the ecological meaning of rattan and its illegal harvesting are associated and represented as a socio-scientific issue. However, research of SSI implementation in the Indonesian-school context was previously conducted by Herlanti et al (2012) to develop argumentation skills of biology undergraduate students on the issue of *E. sakazakii* bacteria controversy. Moreover, Subiantoro et al. (2013) reported initial research of SSI-based learning and students' reflective judgements about the Merapi eruptions and water resource sustainability. Even though these research studies are not broadly nor internationally known, being published in non-international journals, both indicate vigour for developing and spreading SSI innovative teaching in an Indonesian context and this needs to be further supported.

## 2.3 Socio-scientific Issues-based Instruction

### *2.3.1 The conceptual framework of SSI-based instruction*

Levinson (2006) developed an established epistemological framework related to the learning environment in which controversial SSIs can be implemented. Three strands of the framework that include: 1) categories of reasonable disagreement, 2) communicative virtue, and 3) the modes of thought, comprise a pedagogical model of SSIs. The first strand, categories of reasonable disagreement, refers to what students will learn by studying SSIs. Nine categories of reasonable disagreement (Levinson, 2006) clearly define SSIs in science instruction as presenting a broad range of society-based conflicts between science and socio-ethical considerations in which evidence, social values and interpretation about an issue are involved and concern the challenges with which students have to deal. Thus, this definition implicitly states the role of contextualisation of science discourse as a main part of SSIs.

Based on the situated learning perspective, Sadler (2011) asserts the importance of SSIs in providing a meaningful manner by which students could apply their scientific knowledge within communities of practice in science classes. Sharing ideas, knowledges, culture and values based on the conflict provided by SSIs may increase students' interest and motivation to find meaning in their science learning; generally students tend not to think about the science topics that they have learnt unless these are relevant to them personally (Zeidler & Nichols, 2009). This role of contextualization played by SSIs is aligned with the constructivism paradigm in science education. According to social constructivist theory, meaningful learning facilitates students to mobilise their prior conceptions to confront and accommodate new information through socio-cultural experiences adapted towards better understanding of science context (Bischoff & Anderson, 2001; Duit & Treagust, 1998).

The second strand, communicative virtue, represents a framework for discussing activities in which students may share their ideas with each other. This sharing of ideas is the best way to enact different perspectives and reasoning toward conflict

and is one of the criteria in SSIs learning (Lee, Chang, Choi, Kim, & Zeidler, 2012; Levinson, 2006; Zeidler & Nichols, 2009). supporting this strand, based on research conducted by Eastwood, Schlegel, and Cook (2011), four components that participants perceived as important aspects in the SSIs learning environment that they experienced are opportunity for discussion, potential issues for science concept application, transfer of knowledge and skills-based on issue negotiation, and community practice. Thus, SSI-learning requires a situation in which students are allowed or encouraged to share opinions or points of view with their classmates in order to negotiating the issue with an involvement of dispositions such as tolerance, obligation, mutual respect and sensitivity (Levinson, 2006). In addition, Zeidler and Nichols (2009) accentuated an essensial requirement in developing the SSI-pedagogical model to include students' active participation in developing argumentation skills and recognizing reliable evidence and data. An argumentation scenario, debate, or role play, hence, are pointed out to be useful strategies in engaging students to develop critical thinking as well as reflecting upon their ethical-moral considerations (Agell, Soria, & Carrio, 2015). Otherwise, since SSIs challenge students to utilise and adopt their scientific knowledge as well as socio-cultural considerations, the way students negotiate SSIs with others may differ when they need to solve purely scientific problems where students are not expected to consider their attitudes toward generating the decisions (Jho et al., 2014).

The modes of thought, as the third strand, accentuates what students could achieve when dealing with SSIs. The modes of thought represent higher order thinking patterns that include scientific knowledge and reasoning related to ethical considerations (Lee et al., 2013; Levinson, 2006; Zeidler & Nichols, 2009). However, the modes of thought essentially cannot be viewed limited to both thinking and reasoning processes but may be expressed as an argumentation or a decision-making skill as well as epistemological awareness (Albe, 2008; Chowning et al., 2012; Lee, 2007; Lee & Grace, 2010; Patronis et al., 1999; Venville & Dawson, 2010).

The epistemological framework above led to identification of the SSIs-based instruction elements. The first aspect, based on the first strand – the categories of disagreement – is contextualisation of the science topics in terms of the SSI. Students' involvement as well as their attitudes toward SSI-based learning are aspects that arise from the strand of communicative virtue. The last strand, the modes of thought, is defined by the aspect of SSI-based learning objective. Furthermore, underpinned the review based on SSI studies reported in a book of *Socio-scientific issues in the Classroom; Teaching, Learning and Research* (Sadler, 2011), Presley et al. (2013) also developed the framework of SSI-instruction. The framework is composed by aspects: *Design elements, Learner experiences, Teacher attributes, Classroom environment,* and *Peripheral influences.*

*Design elements* refer to the need of an issue based on the society and being strongly connected to science. The issue has an important role not only for providing a controversial problem presented at the beginning of the lesson, but also offering opportunities for students to scaffold their higher order thinking and related skills such as argumentation and decision making during SSI-based lessons. Therefore, ,the issue needs to be well-defined, arranged and constructed into learning scenarios showing the contextual conflict in which students will be engaged with before presenting in a lesson. This consideration to provide the issue toward the SSI-based learning is strongly reflected in a number of research studies (e.g Ekborg, Ideland, & Malmberg, 2009; Feierabend & Eilks, 2010; Lee & Grace, 2010; Levine Rose & Calabrese-Barton, 2012).

Since the aspect of *design elements* emphasizes the role of the SSIs in providing context-based problems that promote the developing of above mentioned skills, learning experiences during the SSI-based instruction also need to be considered to support the achievement of expected learning objectives. Engaging students in multi-perspectives reasoning, argumentation, as well as dealing with the confrontation between science knowledge (including scientific data) and related social dimensions are experiences required for students in SSI-based learning. Along with *the learner experiences* aspect, the *classroom environment* is should be

arranged to support students dealing with their experiences during the SSI-based lesson. In this manner, Presley and colleagues define some key elements of SSI classroom environment such as supportive challenge for participating the lesson, a well-designed interaction in which students can interact collaboratively and in interactive way, and all their ideas be fully respected. In those aspects, it is clearly described that studies on SSI-based instruction reviewed by Presley and his colleagues reflect the need to consider SSI-learning objectives and the affective dimension that represents students' attitudes as well as their involvement during SSI-based lesson.

Successful SSI-based instruction may not be achieved unless the teacher who conducts the SSI-teaching has certain sufficient characteristics related to his/her knowledge on SSI as well as the awareness, attitude and belief about SSI-teaching. These characteristics are categorised as the aspect of *teacher attribute.* However, teacher roles in SSI-teaching practice possibly is not only influenced by intrapersonal factor (i.e teacher attributes) but may also be affected by external factors, such as the school and society culture that support the SSI-teaching implementation, curriculum needs, and SSI-resources. All those external factors are defined as the aspect of *peripheral influences* (Presley, et al, 2013).

Based on above review, it is noticed that those established SSI-based instruction frameworks are compatible to each other: namely the five main aspects provided by Presley and colleagues (2013) and three dimension those offered by Levinson (2006). Nevertheless, Lee et al (2013) offered other conceptual principles of the SSI-lesson program for scientific literacy and global citizen orientation which include: 1) character and values which are represented by three key elements: ecological worldview, social-moral compassion and socio-scientific accountability, 2) dialogical process in which students are able to express of and share their opinion or idea, and 3) multi-perspectives dimensions which reflect position where students can reflect their personal experience in resolving SSI-discourse whether personally, socially or globally.

### 2.3.2 *SSI-based lesson strategies*

The conceptual frameworks above provide a powerful guide for designing and implementing the SSI-based instruction. However, since those mentioned studies had not clearly shown the practical aspects of the framework, defining and analysing the instruction strategies that might useful for SSI-teaching and learning practice is strongly required. Dealing with this need, many research studies have described distinct features of SSI-based instruction strategies which can be highlighted as follows:

*Socio-critical Issues and Problem-Oriented Approach*

Marks and Eilks (2009) offered a great effort in promoting scientific literacy-oriented instruction in chemistry with a concept called *Socio-critical and Problem-Oriented Approach to Chemistry Teaching* which is underpinned by a SSI-framework to "…promote student-active science learning which is motivated using relevant, current and controversial socio-scientific issues" (p. 234). This concept comprises four basic elements: 1) objectives, 2) criteria for selecting issues and approaches, 3) methods (of instruction), and 4) structure of the lesson plans. The structure of the lesson plan underpinned by the approach consists of five phases of instruction and is supported by a functional method for each phase by which the practical aspect of the approach is represented. Based on this framework, a number of following studies were undertaken with various chemistry topics such as shower gels and musk fragrances (Marks & Eilks, 2010) and an issue of doping (Stolz, Witteck, Marks, & Eilks, 2013).

*SEE-EEP Model*

Particularly to address informal reasoning and argumentation skills, the SEE-EEP model was developed to illustrate the multidimensional features of SSI-based lesson practice regarding those skills (Rundgren, 2011). The 'SEE-EEP' standpoint originally refers to six subject area that comprised the model, including: 1)

sociology/culture (S), 2) environment (E), 3) economy (E), 4) science (S), 5) ethics/morality (E), and 6) policy (P). For the practical aspects of the model, a learning strategy was developed and named 'Post it' which, according to its name, involves the activity of posting a written decision in which students express their idea to resolve the issue being discussed.

*The Issue-oriented Model*

Developed by the Science Education for Public Understanding Program (SEPUP) at the Lawrence Hall of Science at the University of California, an issue-oriented model consists of four sequential activities (Lenz & Willcox, 2012): 1) engaging students with a complex issue at the beginning of the lesson to define the context of the lesson as well as the core problem of the issue, 2) gathering and evaluating relevant information or evidence through a variety of activities such as investigation, modelling, or reading, 3) connecting new ideas or knowledge to the basic problem, and 4) making decisions based on the data/evidence and interpretation. For implementation of the model five important components of the model needs to be considered including: discussion, student collaboration, application of evidence, identification of trade-offs, and assessment.

*Bioethics Model*

With a special program called the Collaboration to Understand Research and Ethics (CURE), research conducted by Chowning et al. (2012) promoted critical thinking, reasoning and argumentation skills through in a frame of bioethics education that provided a model of SSI-materials development as well as teaching strategies. The model namely Bioethics 101 curriculum is freely available at http://www.nwabr.org and represents an alternative to SSI-based instruction pathways including: presenting a SSI scenario, ethical awareness reflection, finding and analysing relevant information, identifying stakeholders and their concerns and values, and decision making.

*Character and Values Development Approach*

An attempt to promote character and values education for global citizenship through a SSI-program of genetic modification technology was conducted by Lee et al. (2013). The program was guided by three conceptual principles: 1) character and values, 2) dialogical process in diverse discourse context, and 3) personal-societal-global perspectives. In regard to the first principle, character and values, three elements underline the principle including: ecological world-view, social and moral compassion, and socio-scientific accountability. Thus, based on the principles, five-main pathways of SSI-teaching is developed. For the first phase, the teacher introduces background scientific information and current usage of genetic modification (GM) technology and also raises possible moral/ethical implication of GM technology. This phase is then followed with an introducing of a specific case of GM technology and the teacher encourages students to express their opinions and feelings on the issue. In the third phase, the teacher presents different perspectives of GM technology and arranges students to have an activity in which they are able to define the position toward the issue, find supporting evidence of the position, and participate in a group debate representing the positions selected. In the next activity, for phase four, students viewed a video-clip that showed a hypothetical impact of GM technology on human beings followed by an activity related to designer babies on consideration of moral aspects of GM technology. In the last phase, students participated in a whole-group meeting to provide consensus on the GM issue.

*The Ethical-inquiry Model*

Underpinned by a number of studies about the development of learning strategies for teaching controversial science issues, Saunders and Rennie (2013) proposed a list of criteria for developing a functional strategy to teach SSI that considered: the opportunities for students to develop an understanding of the science concepts, students' engagement and awareness of the issue, individual reflection on personal values related to the issue, classroom discussion, awareness on driving the

expression as well as scaffolding of students' ethical reasoning, and student-teacher metacognition activity. Furthermore, based on their research, a model of ethical inquiry for teaching SSI-based instruction was developed which comprised four main phases of pathway: 1) orientation phase, where students are introduced to the issue and provided with basic background of scientific knowledge behind the issue, 2) reflection and discussion phase, in which students are encouraged to have individual reflections, followed by small group discussions and a temporary decision toward the issue, 3) ethical decision making phase; by class debate, role play, or other activity, with respect to the multiple perspectives that can be taken into account for a justification, and 4) action and metacognition, where students are encouraged to make an action in social consideration and have a deep-insight about what they had learnt.

*Decision-making Training Approach*

Focusing on the development of decision-making skill, research by Gresch, Hasselhorn, and Bogeholz (2013) applied a decision-making training program for students learning SSI in the context of education for sustainable development. The program consists of two main stages: the training of decision-making strategies and the application of the decision-making strategies. For the first stage, three strategies were applied: the compensatory strategy, the non-compensatory strategy, and the mix strategy. The compensatory strategy allowed students to weigh additional values or criteria for making a decision. On the other hand, for the non-compensatory strategy students are allowed to systematically eliminate options of decisions that had unacceptable traits based on the priority or the importance of the criterion of the decision. Furthermore, by combining both compensatory and non-compensatory modes a mix strategy was also applied. In the second stage of the program, students were asked to select the best strategy that might lead them to responding on the decision making task. In a similar objective of fostering students' decision making competence, Bottcher and Meisert (2013) applied those three

strategies in their research to assess different effects of a direct and indirect instruction learning environment in the context of genetically modified crops.

### *2.3.3 SSI and Informal Reasoning*

It is generally agreed among the science education community that reasoning skills is one of the essential goal of science education. The skills are required to be developed so that students can solve any problems in their lives (Yang & Tsai, 2010). Reasoning skills refer to the mental activities by which individuals apply to make meanings of information they obtained to form particular knowledge needed in regard to dealing with such problems in the community. This definition of reasoning is then specified in a science-related field and is called scientific reasoning. Szu and Osborne (2012) explained that scientific reasoning mainly refers to a logical pattern of thinking such as compensation, seriation, or classification, and featured in a form of "if…then…therefore" as a model of hypothetico-deductive arguments. This pattern of thinking is ordinary applied when student is dealing with an observation as well as experimental activity where controlling and manipulating variables on the involved objects are required.

In terms of operational consideration in science teaching and learning practices, Shaw (1996) defined reasoning as the view of constructing and evaluating of arguments which includes *a conclusion* and *premises.* The main claim that is generally expressed is constructed based on premises including facts or information which support the acceptance of conclusion. A conclusion, on the one hand, may represent an answer as well as a position claim toward the scientific question that leads an investigation or experiment regarding a specific problem. Facts or information that play as premises, on the other hand, represent scientific data that are obtained based on a careful observation or through a systematic experiment toward the objects, which needs to be further interpreted for a meaning-making of the data as well as developing a claim or conclusion. It could be viewed by this relationship that the interpretation activities play an important role to bridge scientific data and claim or conclusion by which reasoning skills are necessarily

involved. This definition explicitly mentions the term of 'argument' to-be-performed when competency is expected to be developed by students in their learning activity and afterward.

The description seems to be a simple feature of argumentation as it only involves the components of conclusion and premises. Otherwise, recent studies on the implementation of argumentation in science instruction mostly applied a more complex state of argument referred to Toulmin's argumentation pattern (e.g Dawson & Venville, 2013). As Osborne (2010) explained, Toulmin's argument framework depicts an argument that necessarily occurs to establish a truth formed in a claim that is supported by: 1) *data*, 2) *warrant* which explains the relationship between data and claim, 3) *backings* (the premises of the warrant), or 4) *qualifier* that limits the claim. However, although those components emerge, the claim expressed might be valued to a low quality argument unless it also involves *rebuttals* or counter-arguments. Rebuttals, nevertheless, play a critical role to compare, contrast or critique different backgrounds of reasoning that underpin the argument. This feature reflects the role of argumentation as a basic foundation of scientific reasoning as well as a way of understanding in science where evidence underpins the process to generate a state of knowledge, belief or decision within constructivist views (Dawson & Venville, 2013; Osborne et al., 2012; Yang & Tsai, 2010).

Since the pattern of logical thinking represents a formal approach in a scientific framework that is typically logical-mathematical, this reasoning is defined as formal reasoning (Shaw, 1996). Formal reasoning is a main form of reasoning applied for domain-specific context or knowledge, in well-defined problems, as well as assumptions that drive the meaning making upon data/information (Wu & Tsai, 2007; Yang & Tsai, 2010). In cognitive psychology, as well as science education, knowledge typically has been developed by this mode of reasoning by which attributes or variables of the object and problems are specifically defined and interpreted through deductive inference (Shaw, 1996). However, in a real life context, students are often facing uncertain issues where the science context

sometimes is interrelated to other contexts, such as economics, social values, or culture. These issues may not emerge in a well-defined variable or attribute and could have a various alternatives to be solved. Thus, dealing with such an issue challenges individuals who may apply not only their scientific knowledge but also their concerns about any other consideration in an attempt to make a decision to solve the problem.

In contrast to formal reasoning, informal reasoning is applied outside the formal contexts of mathematics and symbolic logic and involves reasoning about causes and consequences, advantages and disadvantages, pros and cons, and opinion of ill-structured problems that have no definite solution and often involve inductive reasoning (Means & Voss, 1996; Zohar & Nemet, 2002). Shaw (1996) stated that there are three characteristics of informal reasoning which distinguish it from formal reasoning, including: 1) although it may contain premises and conclusions, informal reasoning is not structured like its counterpart since the premises are frequently not clearly stated, 2) inductive inferences are more likely preferable, and 3) this type of reasoning is often used when dealing with an occasion where reasons could be both for and against the conclusion. Moreover, as informal reasoning is a cognitive processes by which an individual constructs his/her argument (Wu, 2013) this kind of reasoning could be applied to evaluate and generate alternative decisions or arguments in response to uncertain issues that lack a clear-cut solution (Sadler, 2004). Understanding the pattern of students' informal reasoning skills is useful for reflecting the science learning experienced by students, regarding its purposes on scientific literacy (Sadler & Zeidler, 2005). Therefore, informal reasoning is valuable as an essential outcome of SSI-based instruction (Wu & Tsai, 2011; Zeidler, 2014).

Dealing with the informal reasoning orientation in SSI teaching and learning practice, a number of research studies offer distinct perspectives, particularly in regard to examining the method of informal reasoning and the interrelation between informal reasoning and other SSI-learning aspects (e.g Yang and Anderson, 2003; Zohar and Nemet, 2002). As an example, on the basis of argumentation skills as a

central manifestation of informal reasoning, Zohar and Nemet (2002) employed dilemmas in genetics to examine students' biological knowledge and whether mastery of that knowledge influences argument construction. For this research purpose, an experimental design was applied which involved two groups of students that were assessed for biological knowledge and argumentation skills before, during and after the instruction. Worksheets completed by students and audiotaped discussion particularly in the experimental group were two of the main resources of argumentation skills data. For genetic knowledge data, pre and post-test sets were used with the experimental and comparison groups. A dual approach of analysis was applied including qualitative analysis for audiotaped discussion and quantitative analysis for content knowledge. Major findings of the research showed that: 1) there was an increasing number of valid biological knowledge applications used by students in constructing arguments, 2) a significant difference of knowledge test scores was showed where the experimental group obtained higher scores than the comparison group, 3) an increased intensity of the complexity of arguments and number of justifications produced by students when applying reasoning abilities.

A study aligned with the ideas of Zohar and Nemet (2002) was carried out by Yang (2004). Working with 45-male and 45-female grade-10 students, the research was aimed to examine how the participants use theory and evidence in evaluating an issue about the use of underground water. Besides taking the related knowledge into account, metacognition, personal epistemological beliefs and gender were factors that were considered in this study. An instrument with open-ended questions was employed in order to obtain the data. To determine the degree of knowledge utilized by participants as well as how to use theory and evidence toward resolving the issue flow map analysis was used. Flow map analysis is a method of examining the sequence of idea and their possible networking within narrative expression either written or spoken in the stream of discourse (Yang, 2004). Statistical analyses employed included chi-square, paired *t-test*, one-way of ANOVA and correlation analysis. According to the analysis, after attended the designed instruction students had an improvement on the sequential way they organized the concept to respond

to the issue being discussed. This trend also occurred for linear concepts application, but did not happen for the complex linkage of knowledge. One particular interesting result occurred was a weak association between students' knowledge about the issue and their ability to identify the information required to make a better judgement. Furthermore, students were unsure about the background of information and knowledge underpinned their argument.

Those aforementioned research studies focused on argumentation and decision-making generated by students on topics related to SSIs but which did not explicitly discuss reasoning modes, or informal reasoning in particular, and how the skill could be developed. In this regard, an effort to gain insight into the reasoning modes related to information preferences proposed by 12th grade students in Taiwan was conducted by Yang and Anderson (2003). A dilemma about nuclear energy use was employed and students' responses were examined within three variables in this study. First, information preference was either scientific or social information concerning the SSI employed and assessed by a paper and pencil test. Second, the reasoning mode pertained to the information used toward making a decision as assessed by interview. Third, student characteristics including gender, school performance, self-expectations, learning styles, family attributes and personal beliefs system were considered. Regards the first variable, it was revealed that most participants did not exclusively chose one source of information though they were classified as either 'scientifically oriented' or 'socially oriented'. Following this result, analysis of interviews showed that students' beliefs, values and emotions were considerably influenced by the diverse reasoning modes expressed by participants. Moreover, a valuable aspect offered by this research was recognizable reasoning modes that included 'scientifically' and 'socially' oriented.

Another study that especially attempted to examine informal reasoning features using socio-scientific issues was conducted by Sadler and Zeidler (2005). With a qualitative approach through interviews they examined the informal reasoning and morality consideration applied by 30-college students to negotiate and resolve genetic engineering dilemmas which include six issues. The most valuable aspect

produced by this research was a conceptual framework for analysing informal reasoning patterns. Thus, by the developed framework informal reasoning could be categorized into three patterns namely: intuitive, emotive and rationalistic. *Intuitive* informal reasoning was mainly based on immediate feelings or reactions either positively or negatively, and these contribute to the eventual resolution of the issue. *Emotive* informal reasoning relies on moral emotions, empathy and sympathy that represent a sense of care toward others who might be affected by the decisions made. Although students may involve various considerations toward the SSI being discussed such as side effects or issue of interest, *rationalistic* informal reasoning was typically expressed solely on reason and logic to formulate and support the positions. There were four key findings of their research. Firstly, those three modes of informal reasoning were applied by participants with various degrees of consideration for each reasoning pattern where rationalistic mode was relatively high for these issues. Secondly, the results showed integration of multiple patterns of informal reasoning expressed by students which means that the expression of informal reasoning is not only a single-based pattern but also potentially relied on the combination of each pattern. Thirdly, there was an extent to which the context of the issue influenced the mode of informal reasoning expression, and fourthly morality, personal experiences, emotive factors and social considerations were factors that may influence the informal reasoning of participants for decision-making about SSIs.

Following Sadler and Zeidler, Dawson and Venville (2009) employed a qualitative approach in their research to explore Australian high-school students' argumentation and informal reasoning about biotechnology and whether there is a relationship between those skills with students' scientific literacy. Ten Year-8 students, 14 Year-10 students and six Year-12 students participated in the research and were involved in semi-structured interviews conducted at the end of academic year. There were three specific features of methodology aspect applied by the research. Firstly, participants had not been taught about argumentation process, therefore researchers could obtain their argumentation in natural way similar to how they were asked by the teacher in non-test situation. Secondly, as the interviews

were conducted in monologic discourse where students only responded to questions from researcher, they did not have the opportunity to express rebuttals, so the researchers constructed a scheme to analyse argumentation of Level 1 – 4 as described in Table 2.1. Thirdly, besides the scheme of argumentation, the research was also used the informal reasoning analysis frameworks developed by Sadler and Zeidler (2005) to define the pattern of informal reasoning expressed by students as intuitive, emotive or rationalistic as described in Table 2.2. According to the data analysis, the research showed that the majority of arguments expressed by the group of participants were at Level 2 and classified as intuitive or emotive. Moreover, for Level 4 arguments and the rationalistic informal reasoning mode were accounted for far less than those other categories. Thus, these data represent an inconsistency between informal reasoning and argumentation with the goal of scientific literacy in regard to SSI being discussed. These researchers suggested that the context of SSI implemented in their study such as cloning and forensic testing may be influenced by the results of those dominant argumentation as well as informal reasoning modes.

Table 2.1 Level and description of argumentation quality

| **Level** | **Description** |
|---|---|
| Level 1 | Claim (statement, conclusion, proposition only) |
| Level 2 | Claim and data (evidence supporting the claim) and / or warrant (relationship between claim and data) |
| Level 3 | Claim, data/warrant, backing (assumption to support warrant) or qualifier (conditions under which claims are true) |
| Level 4 | Claim, data/warrant, backing and qualifier |

Table 2.2 Category and description of informal reasoning patterns

| **Category** | **Description** |
|---|---|
| Rationalistic | Logical, uses scientific understanding and language, weighs up risks and benefit, advantages and disadvantages. |
| Intuitive | Gut feeling. Immediate response, strongly held, often a negative response, personal, often precedes rational or emotive. |
| Emotive | Emotional response towards stakeholders, care, empathy, sympathy, concern for plight of those affected. |

(Dawson and Venville, 2009, p. 1431).

Following up their previous research, Venville and Dawson (2010) carried out an embedded case study with a quasi-experiment to explore the impact of an intervention of classroom-based argumentation on high school students' argumentation skills, informal reasoning and conceptual understanding. Through written pre and post-instruction surveys, data about those abilities were obtained from two Year-10 classes of experiment groups and two others as comparison groups. Within the same topic of genetics, the experiment group participated in explicit argumentation lessons while the comparison group did not. As in their previous research, the authors' scheme level of argumentation was employed for analysis because students provided written and monologic responses without the opportunity to express a rebuttal. Especially for the informal reasoning pattern, a few modifications were applied to the previous scheme for which researchers defined the patterns as four categories. Further, results of the research revealed that: 1) the explicit teaching and practice of argumentation skills give good impact of both the level of argumentation and the quality of informal reasoning, and 2) the argumentation intervention had a modest impact toward students' understanding of genetics.

Since their previous research studies did not specifically take the teachers' role into account, Dawson & Venville (2013) carried out a further research about genetics-SSI which tried to examine the impact of teaching strategies introduced by the teachers toward their students' argumentation skills, informal reasoning and genetic understanding. Using a similar framework of research method as their former studies (Dawson & Venville, 2009; Venville & Dawson, 2010) through a quasi-experiment with mixed methods of data collection, four key findings were revealed. Firstly, although the teachers participated in a similar professional learning session on argumentation, the teaching strategies on argumentation were applied in a various ways. Secondly, a significant difference in the experimental group's post-instruction compared to their pre-instructional levels of argumentation occurred, whilst this was not so for the control group. Regarding the informal reasoning, as the third result, the experimental group's informal reasoning pattern significantly changed from pre-instruction to post-instruction, and again, this change did not

occur for the control group. Lastly, the gain of the experimental group's mean score of the genetic understanding was significantly more than the control group and, therefore, this indicates a better improvement by the group. Furthermore, these research findings strengthened the framework about the important role of teacher in facilitating student discussion as well as argumentation.

Those mentioned studies have provided a number of specific methods on examining informal reasoning related to different context of socio-scientific issues. It could be recognized that, for some extent, those research studies did not explicitly examine the role of formal reasoning and how it may be associated with informal reasoning. Wu and Tsai (2007) explained according to the dual-process theory, formal reasoning actually relates to informal reasoning based on two distinct cognitive system, one as implicit (system 1) and another as explicit (system 2). System 1 or associative system is unconscious, pragmatic, contextualized, rapid, parallel, and automatic. System 2, on the other side, is conscious, involves logical and abstract thinking, and sequential. On the basis of past experiences (including prior knowledge and personal beliefs instantaneously retrieved from long term memory), system 1 helped student develop an initial mental model about the problem and she/he frequently made an intuitive decision accordingly. However, the learner can also then utilize system 2 to produce hypothetical thinking, in which the initial mental model is revised until a conclusion is obtained. Following this dual-process theory, Wu and Tsai (2007) developed an integrated framework on examining student informal reasoning skills that included qualitative indicators and quantitative measures and analysed informal reasoning skills of 71 Year 10 students related to nuclear energy usage which were examined through an open-ended questionnaire. By the instrument, students were asked to write their opinion about building nuclear power plant in Taiwan and how they would make a decision on the issue. Results of the study revealed that about 25% of students made their decision upon the issue intuitively. Those who made evidence-based decisions tended to easily change their positions after receiving relevant information about the issue. The framework of informal reasoning analysis developed in this study has valuable contribution for further study about reasoning skills related to SSI.

In an attempt to gain insight about the factors that might influence informal reasoning performance, Wu and Tsai (2011) conducted another study to examine the relationship between students' scientific epistemological beliefs (SEBs) and cognitive structure regarding nuclear power usage. The data of the research were collected with a questionnaire-based instrument for SEBs, interviews for cognitive structure, and an open-ended questionnaire for informal reasoning, and these were given to 68 10th grade students involved in the study. Based on the research findings: 1) there is an extent to which 'belief bias' influences students to ignore counterarguments after they made a decision about the issue. Belief bias is "a tendency to evaluate the validity of an argument on the basis of whether or not it agrees with the conclusion" (p. 395); 2) Students' scientific epistemological beliefs (SEBs) play an important role in the reasoning and decision-making quality, particularly in providing rebuttal component of argument; 3) The more rich the cognitive structure, a higher level of information processing and the quality of conceptual understanding related to the issue potentially influences students' informal reasoning quality. This research, however, accentuated a study that Yang and Tsai (2010) reported previously about the relationship between informal reasoning and the epistemological perspectives in elementary school students regarding earthquake prediction and well-drilling project and land subsidence.

Besides the methodological aspects, across those various studies reviewed above there is a wide spectrum of conceptual frameworks for investigating informal reasoning which can be more highlighted as follows:

1) Informal reasoning skills can be expressed in a various patterns or modes; a number of studies have provided different frameworks and methods for investigating these (Yang & Anderson, 2004; Sadler & Zeidler, 2005; Wu & Tsai, 2007).
2) Some evidence showed a strong relationship between informal reasoning expression with science knowledge understanding (Yang, 2004; Zohar & Nemet, 2002) as well as the level or complexity of arguments (Dawson & Venville, 2009; 2013). However, it is also suggested that the context of the

issue has a particular impact on the performance of each skill and the relationship (Sadler & Zeidler, 2005; Venville & Dawson, 2010; Wu, 2013).

3) Besides the context of the issue, a various degree of considerations including mental strategy, personal beliefs, social values, emotions, learning and social experience, and perspectives are important factors that could influence students' informal reasoning expression and argumentation (Lee, 2007; Sadler & Zeidler, 2005; Wu & Tsai, 2007; Yang, 2004; Yang & Anderson, 2003).
4) Particularly in respect to personal beliefs, some studies reported an impact of cultural epistemology that hold by students and may drive students' decision-making (Morin, et al, 2013; Topcu, Tuzun, Sadler, 2011; Wu, 2013; Zeidler, et al, 2013).
5) Since relevant-scientific information is considerably required for generating the reasoning and providing the arguments, information processing skill which includes identifying and assessing the information is strongly needed to be managed by students (Yang & Anderson, 2003). However, the absence of designed learning environment in which students have a limited occasion to practice developing this skill, as is represented by traditional science classrooms, they lack the ability to demonstrate how they can express their reasoning and decision-making (Yang, 2004). Therefore, attention needs to be given to developing science education programs, particularly in regard to SSI-implementation which is able to assist students to develop these skills (Sadler, 2004).
6) Overall, those highlights reflect a considerable impact of learning habit as well as science classroom culture in which students experience their science learning (Zohar & Nemet, 2002). Thus, since SSI-based instruction can be an important vehicle for students to practice their informal reasoning and argumentation skills, also the nature of science (NOS) conceptualization, information processing skills, and development of science knowledge understanding (Sadler, 2004), it is necessary for science teachers to organise the science classroom so that those students' skills could be well developed (Lee, 2007).

## 2.4 Teachers' and Students' Experience in the SSI Innovation

### *2.4.1 Innovations in science education and teacher professional learning*

Promoting innovation in science education, particularly related to curriculum and its implementation, certainly requires teacher preparation because she/he plays an important role in interpreting as well as actualizing the innovation into teaching practice (Bakkenes, Vermunt, & Wubbels, 2010; Konings, Brand-Gruwel, & van Merrienboer, 2007; Peers, Diezmann, & Watters, 2003). Therefore, teacher professional learning or professional development is recognized as a useful medium to take account of this preparation (Davis, 2003; Pinto, 2005). Guskey (2002) asserted that well-designed teacher professional learning attempts to initiate teachers to review and transform their beliefs, attitudes and perceptions. Bitan-Friedlander, Dreyfus, and Milgrom (2004) suggested that successful teacher professional development for introducing innovation is when teachers are motivated and be able to implement such innovation into their class as well as make necessary adaptations for future needs.

Clarke and Hollingsworth (2002) notably used a specific term of "teacher change" and described it from six perspectives: 1) change as training which is something that is done by teachers so that teachers are "changed", 2) change as adaptation where teachers "change" or doing an adaptation on their teaching practice in response to something, an expected condition toward their classroom, 3) change as personal development, where teachers are looking for or involving into a particular development program to develop their skills or performance, 4) change as local reform as a form of a change which personal growth reasons, 5) change as systemic restructuring that related to policies of the system, and 6) change as growth or learning where through a professional activity teachers are themselves learners and work in a learning community. Furthermore, based on their review of the history of teacher professional development programs that were ineffective, they pointed out that the perspective of change as growth or learning should be a fundamental framework. The framework emphasizes their role as active learners so that teachers'

professional dimension could be shaped through reflective participation in the learning program and through practice.

Considering the importance of reflective engagement in teacher learning programs it is suggested that programs should be viewed through a frame of constructivist learning theory in which teachers are able to express their prior knowledge and beliefs as well as consider and understand the reasons for their involvement and role in the program (Davis, 2003). Besides taking into account the reasons and benefit, investigating the way by which teachers learn and have experience in the context of implementation of an innovation seems to be a crucial issue in the field of teacher professional development research (Konings et al., 2007).

Dealing with the reflection about how teachers learn through their teaching role, Bakkenes et al. (2010) revealed four important issues. Related to the way they learnt, teachers reported that they learn mostly by experimenting and reflecting upon their own teaching practice. The second issue of reflection reported by the participants was the learning outcome; changes in knowledge and beliefs as well as emotions tended to be easier than change in teaching practice. Between those issues, meaning-oriented learning which was represented by the intention of practice that underpinned those changes may promote the change in regular practice of the teachers' role. Lastly, regarding the learning environment (i.e where the professional development program is undertaken), an organized learning environment indicated a better environment for teacher learning by which, for instance, teacher will be able to has a little experience on negative emotions, rather than informal learning in the workplace.

### *2.4.2 Models on teacher professional learning*

How a teacher perceives any educational innovations as well as professional learning program in which teachers are challenged toward the innovations has been an important topic in teacher education studies. Of particular interest is the progression of models that were developed and administered in former research (Simon & Campbell, 2012; van Driel, 2014). In their review, for example, Simon and Campbell (2012) cited some models such as three domains of development (by

Bell and Gilbert) or continuing professional development (CPD, offered by Aileen Kennedy). When considering Simon and Campbell's (2012) description, van Driel (2014) reviewed Guskey's linear model of teacher change, the three-types of model offered by Sprinthall and colleagues and the *Interconnected Model of Teacher Professional Growth* (IMTPG). Further, amongst the various models, the IMTPG model developed by Clarke and Hollingsworth (2002) represents an integral framework for analysing teachers' development growth since "it is possible to understand each teacher's development in a detailed way" (van Driel, 2014, p.148). IMTPG characterised as follows:

1) The model comprised by four domains: (1) personal domain (PD) which represents knowledge, belief and attitude, (2) external domain (ED) includes external source of information or stimulus, (3) domain of practice, i.e. professional experimentation (PE), refers to teacher performance in doing teaching activity with a "new" particular strategy or technology, and (4) domain of consequence, i.e. salient outcomes (SO), represents additional outcomes which might be achieved or performed either by students or teacher such as the role of teacher control or student motivation.
2) Those four domains are involved in dynamic interrelation toward knowledge as well as skills development that may be obtained by teachers. The model suggests that change of teachers' skills or performance will be viewed by the mediating processes of "reflection" and "enactment". Reflection refers to a mental activity to evaluate and reconstruct experience, knowledge or insight. Enactment, on the other hand, refers to an action that occurs based on the change of knowledge, belief or attitude that has experienced before.
3) Different with other model(s), interconnected model applies a non-linier framework in its implementation. This implies on the view of its analysis where through its mediating processes it should be noted that the change of one initial domain possibly not only change another domain in one-way effect, but it could be a reverse effect to initial one.
4) In term of how the model applicable to identify and describe the pattern of change that occurred, there are two distinct patterns of change recognized.

> First, *change sequences* which involves "two or more domains together with the reflective or enactive links connecting the domains and empirical data present to support both the occurrence of change in each domain and their causal connection" (p. 958). Simply described, a change sequence occurs when a single change in one domain could lead to change in another. The second pattern of change namely *growth network* will be emerged if "data is more demonstrated the occurrence of change that is more than a momentary, then this more lasting change is taken to signify professional growth" (p.958).

Based on its attributes, there are three functions that could be applied by the model. First, according to data specified to each domain, processes of change that might be occurred in one domain (and associate to change of another) and the structural pattern of professional growth, it is notably defined that the model plays a functional tool for the categorization of teacher change. However, if this function applied on the context of conducted program, in an attempt of an arrangement of a professional development program in which such values of change (i.e knowledge or skills) are would like to be promoted, the model also may suggest the possibility of mechanism for further implementation of the program. Lastly, as an interrogatory tool, the model "facilitates the framing of specific theoretical and practical questions" (Clarke and Hollingsworth, 2002, p. 957), such as "What are the possible pathways leading to change in teacher knowledge, beliefs or attitude?" (p. 958). Regarding these functions, a study conducted by Justi and van Driel (2006) accentuated how applicable of the model to examine teachers professional change.

Clarke and Hollingsworth (2002) study was aimed to examine the teachers' knowledge growth that occurred within the context of a professional development project concerned with models and modelling in science. Working with five science teachers in the basis of participatory action research, three phases of project were carried out. In phase one, teachers' initial knowledge on models and modelling was examined through a questionnaire and interview. Following this part, a-four meeting that held over a period of six weeks was conducted in which the

participants were involved in learning activities concerned with their knowledge on models and modelling. At the final phase, each teacher arranged and conducted her/his own project on models implementation in their class. Based on data gathered during the projects, there were 45 representations of teachers' growth identified and classified either as change sequence or group networks regarding these following aspects: content knowledge, curricular knowledge, and pedagogical content knowledge (PCK). Therefore, based on the analysis of those data it is clearly noted that by the implementation of the IMTPG model the researchers found possible to analyse the change of each domains and the establishment of relationships between the changes so that the processes of development of each participants' knowledge possibly to be understood. Supporting those results, a study conducted by Justi and van Driel (2006) provided a comprehensive description upon the usefulness of the model as a framework for designing a professional development project as well as for analysing and understanding the growth of teacher's knowledge within the context of models and modelling in science education practice.

### *2.4.3 Science teachers' experience in SSI implementation*

The importance of investigating science teachers' experience as well as perceptions of SSI implementation in science classroom has been promoted by a number of studies. Prior research conducted by Reis and Galvao (2004) revealed a contradictory view held by teachers regarding SSI-based instruction. On one side, teachers perceived SSIs have strong potential for scientific literacy-oriented achievement as the issues provide media for students to develop their decision-making skills. However, on the other side, SSI learning may inhibit the teacher's responsibility to assist students to successfully pass their final examinations. Thus, the problem of concept attainment which curricula tend to emphasize, the time required, and teachers' experience about the intended teaching, are issues which need to be considered when including SSIs in the curriculum. Another study carried out by Gray and Bryce (2006) revealed that teachers have inadequate knowledge and skill to deal with the social, moral and ethical dimension of SSI. Moreover, they

stated that it is important that teachers are given opportunities to reflect on their own beliefs when confronted with controversial issues, so that the teachers will be able to reassess what these may imply or mean for their own teaching practice.

The influence of teachers' personal values and concerns about an innovation on their teaching practice has been considered in science education reform because teachers "are teaching whatever they feel is important without much contact with reform ideas" (Lee & Witz, 2009, p. 932). Related to how teachers may have insight toward their own epistemic beliefs and awareness of those factors that may influence their perceptions of SSI-based teaching, Lee, Abd-El-Khalick, & Choi (2006) developed a Likert-type questionnaire on teacher perceptions of SSI-based teaching comprising 20 five-point items divided into three scales: the necessity of introducing SSI, situational factors related to addressing SSI in class, and teacher's epistemic belief regarding SSI teaching. The questionnaire provided a useful instrument for assessing teacher perceptions of SSI teaching because it encompassed important dimensions on how teacher perceive themselves toward SSI implementation. Moreover, the research identified factors that impede teachers' teaching practice on SSI, namely teachers' epistemic beliefs regarding SSI, the concern on their own personal values and its impact on students' views, the lack of pertinent learning material as well as time to prepare it, and difficulties to select teaching strategies regarding the moral and ethical dimension. Subsequently, other results of studies (Barrett & Nieswandt, 2010; Wolfensberger, Piniel, Canella, & Kyburz-Graber, 2010) identified similar factors including teachers' concerns about their own personal values and their influence on students' values, the lack of learning materials, the lack of time for planning and preparing, and the difficulties to implement effective approaches and evaluate students' moral-ethical dimensions.

Dealing with factors that may impede teacher readiness to teach SSIs, a well-prepared professional development program is needed with moral-ethical reasoning as well as a better science content knowledge on SSI (Gray and Bryce, 2006). This approach is evident as shown in qualitative-based research by Anagün and Ozden

(2010) where pre-service science teachers considered themselves incompetent to implement SSI-based learning due to the lack of a specific program for teaching SSI, even though they were interested in SSI. In alignment with these studies, a Kara (2012) suggested that in order to assist teachers in preparing the implementation of SSI-based learning, it is beneficial to understand teachers' self-efficacy beliefs toward his/her teaching practice on SSI as well as factors that relate to teachers' awareness of adopting SSI teaching.

In their research, Ekborg et al. (2013) showed that the seven teachers who participated in their study talked about the importance of SSI discourse toward argumentation skill development, but they were unsure how to support it. Moreover, the authors articulated that even though teachers felt comfortable to work with SSIs in their teaching practice, they just provided the issues to generate students' interest in the beginning of the lesson but did not emphasize the interrelation between the science content with ethical aspect. Ekborg and colleagues argued that implementing SSI discourse in science classroom does not immediately encourage students to achieve the expected learning objectives (such as argumentation as well as decision-making skills) unless the teacher ensures that he or she is able to design and organize the learning environment to align with the SSI-based model. In doing so, teachers who are expected to implement SSI-based learning need to be well-trained for such innovation by being concerned about input of new instruction idea, reflection of pros and cons of the innovation and perceptions toward the knowledge required. Moreover, it is necessarily to synchronize the reform efforts with teacher's personal values and belief beyond the theoretical ideals suggested to the teacher (Lee & Witz, 2009). This means that "reformers should pay more attention to teachers' inner aspects, not regarding them as one of the major barriers for moving forward" (p. 957). Further, the reform should depart from teachers' own personal meaning of SSI-teaching, values, and also personal concerns, helping them to enlarge their view of science as well as science teaching.

### *2.4.4 Students' experiences in and perceptions of the SSI learning*

Whilst many studies on SSI implementation have provided considerable evidence on student achievement (see section 2.2), nevertheless, research that might show how students perceive the SSI learning environment, particularly in respect of their affective dimension, could make a positive contribution to examining the role of teacher and students and the quality of their interaction in the SSI classroom (Eastwood et al., 2011; Fraser, 2001).

In the context of climate change, Feierabend and Eilks (2010) developed and implemented SSI lessons where the underlying chemistry concept was taught by a socio-critical and problem-oriented approach (Marks & Eilks, 2009). Based on a Likert-type questionnaire, it was revealed that (1) students' interests were in multi-disciplinary topics rather than pure science (chemistry) units, (2) students perceived more understanding on climate change topic, (3) students perceived the group activities including business games that engaged them in working and discussing together, and (4) students enjoyed the lessons. Moreover, the research examined students' perceptions of the learning achievement, such as content knowledge and social skills and the teaching strategy used by the teacher. Using the same lesson framework, with the context of bioethanol usage (Feierabend & Eilks, 2011) the authors investigated students' decision-making skills, as well as teachers' and students' experiences. Students' perceived the lessons as being interesting and there was a positive change in their chemistry learning particularly working autonomously as well as group work. Moreover, the students perceived that they learnt about critical thinking toward making a decision (for the issue) and reflecting upon the societal and environmental problems.

Research by Ottander and Ekborg (2012) that involved 1500 lower secondary students was designed to investigate their experience in learning with six SSIs in terms of attitudes and interest before learning, the situational characteristics of the SSI work, as well as students' cognitive and affective outcomes. The results showed tha students 1) viewed the issues as mostly interesting and considered them to be relevant to their daily life, 2) could learn facts and science, search information, and

generate opinions, 3) were satisfied with social interaction during the group work discussion, and 4) perceived that the more interesting the issue, the more they learnt. The evidence is likely to corroborate research findings previously conducted by Tal and Kedmi (2006) when most students indicated that the SSIs being implemented were interesting, relevant to their life, and made them enjoy working in a small groups and hold discussions. Moreover, an important implication offered by these studies is the need for learning strategies to facilitate group discussion that are developed by the teacher who is willing to teach SSI-based instruction.

To look at the way students perceived their experience in the SSI learning as a form of innovation, Morris (2014) developed and implemented a SSI-instruction program based on the curriculum reform program called *Twenty First Century Science* and involved female secondary level students from one school. Through observations of the lesson sequences, sampling across the science subjects (physics, chemistry, biology) assessing students' achievement, and interviews, data about students' perceptions of SSI-learning environment were collected. The research findings showed various views on situations as well as activities that were experienced, such as a concern about disruptive behaviour that occurred during the lesson and practical activities which allowed students to generate a great number of responses toward the issue. In particular, students asserted that the SSI learning led them to have and value discussion and debate-mode activities. One important result was that female students in this study considered SSIs to not be 'proper' science and they held both positive and negative responses to such issues being implemented in their lessons.

Dealing with the relationship between knowledge, interest and attitude in SSI classroom, Stenseth et al. (2016) investigate the extent to which the topics of nuclear power and human-induced climate change generated interest and knowledge that may lead students' attitude toward these two SSIs. The research findings indicated that both personal interest and topic knowledge may predict students' attitude toward SSIs, highlighted by the context-specificity of the psychological mechanism involved in attitude formation. If the issue was perceived

to evoke less involvement and engagement among students, they mainly rely on their knowledge to form their attitude. On a particular SSI, students are likely to have different perceptions regarding the cultural context and, in this respect, teachers should be aware about students' interest and engagement which might be more important than their knowledge in the SSI classroom. These findings align with the previous study by Rundgren (2011) which showed that students' attitude toward SSIs is related to the attribute of different SSI topics.

Although limited in number, nevertheless, those studies reviewed above reflect a valuable meaning of understanding students' perceptions of SSI-based lesson in a wide spectrum such as enjoyment, attitude, or a view of the functionality of SSI in their science learning. Furthermore, distinct forms of instrument or assessment methods used by those research studies provide a useful framework or strategy for further research on SSI learning environment.

## 2.5 Summary and Marking the Gaps

Based on above-described literature review, it can be highlighted that:

1) An important role of socio-scientific issues (SSIs) for contextualising science teaching and learning practice is represented by a number of studies and potentially useful for promoting an orientation of scientific literacy as well as character education in biology instruction in Indonesia. Hence, supporting this framework, some SSIs in the context of Indonesia provide valuable examples for developing and implementing SSI-based instruction in secondary biology classrooms in Indonesia.
2) Dealing with the practical dimension of SSI-based instruction, an understanding on some teaching and learning strategies of SSI has to be considered. To come to this consideration, some research studies have provided useful instances on theoretical as well as practical features of SSI-based instruction strategies. Thus, this research study has adopted these strategies frameworks to support its objectives.

3) As one of the important skills in SSI implementation, informal reasoning is defined as an objective of this research. Many frameworks on investigating this skill have been provided by a number of studies. However, a framework which analyses informal reasoning into three categories namely: intuitive, emotive, and rationalistic patterns, is adopted and implemented in this research study.
4) According to many studies, this research is also considering the importance of teachers as well as students perceptions of an innovation in their classrooms experiences. Therefore, the perceptions of SSI-based instruction, as an innovation in secondary biology classrooms particularly in Indonesia, from both students and teachers are also valuable objectives for this research study. Furthermore, a number of research in the area of SSI as well as learning environment studies have led this research to develop a particular framework to investigate the perceptions.

In alignment with these highlights, this research aims to address the gaps in current literature in the following ways. First, whilst previous studies mostly used global-based issue as the context of the research, this research emphasises and applies local-based SSIs in the context of Indonesia. From this research, the functionality of local SSIs will be examined in term of the innovation practice and potential findings that may enrich the philosophical as well as conceptual perspectives regarding the role of SSI contextualisation in science education research.

Second, a careful review on the literature led this research to recognise the substantial dimensions of SSI teaching and learning frameworks which is really useful for assessing the meaning of SSI instruction either from students' or science teachers' perspectives. However, it is rare to find research that comprehensively and sophisticatedly discuss the way students as well as teachers perceive SSI instruction based on the frameworks. From the students' point of view, most studies tend to look at student achievement in particular dimensions with a lesser emphasis on affective aspects. Furthermore, to date the instrument for assessing student perceptions of SSI-based instruction could only be found in a very limited number

of studies, especially for biology classroom. Therefore, based on the frameworks, this research fulfils an important need of assessing student perceptions of SSI-lesson comprehensively. On the teachers' point of view, research about SSI-innovation practice in the framework of teacher professional development is also rare. Thus, as this research underpins its idea to promote SSI-based instruction as an innovation in the framework of teacher professional learning program, it means that this research would provide a valuable contribution to the topic in this field of research. In sum, this research may address the lack of research in SSI-innovation practice in regard to student as well as teacher experience and perceptions, and consequently reveal the factors that potentially support or impede SSI-implementation.

Finally, dealing with student informal reasoning, this current research aims to address the research gap by explaining the extent to which pupils or students use their perspectives or orientations to generate their reasoning in responding to various SSIs being discussed, and also the possibility of whether the perspective or orientations would change due to the learning experience provided through the innovation in this research.

# CHAPTER 3

# RESEARCH METHODOLOGY

## 3.1 Nature of the Research

Identifying the nature of the research involves obtaining an insightful understanding into the research paradigm underpinning the research. It is really important to understand the research paradigm because it guides the researcher in designing as well as in implementing the research (Treagust, Won, & Duit, 2014). This research emphasizes the exploration of biology teachers' and students' experiences during teaching and learning with SSIs-based instruction. This research was not intended to evaluate the effectiveness of the innovation on student achievement before and after implementation of the innovation. Rather, the research was designed primarily to understand teachers' views on how they perceived the innovation, their reflections about the innovation and its implementation on the ground, and how students shared their experience after the SSIs-based learning. Instead of using the innovation as an external stimulus and examining its impact on student behaviour, this research examined how teachers as well as their students responded to the innovation. Thus, according to the characteristics and features of contemporary paradigms in science education research, this research is framed within the interpretivist paradigm (Treagust, et al., 2014).

Candy (1989) explicitly states the common assumptions that are shared by interpretivist researchers. For the interpretivist researcher, having an understanding about the individual case is of main importance rather than developing generalisations. Moreover, any field of research is multifaceted and needs to be investigated holistically and not fragmented as independent or dependent variables as in positivism. Furthermore, because every case has its own context, it is recognised that research with an interpretivist perspective is value-laden and this will influence the framework, the design as well as the focus of the problem being investigated. Garrick (1999) emphasised that an understanding of participants'

lived experiences is based on what they could share about their lives in context. In the case of teachers, their lived experiences are immersed in and shaped by discourse of classroom practice, and this knowledge is important in interpretive studies. Sharing lives in context experiences means to view each participant in interpretive research as an individual who has inner capabilities to judge, perceive and make a decision.

The core feature of interpretivist research is "the localized meaning of human experience" (Treagust et al., 2014, p.7) by which knowledge construction of the research is dependent on the meaning-making process of participants' experiences that reflect their ideas, values and beliefs in particular contexts and within the dynamic nature of science classrooms (Taylor, 2014). Dealing with the origin of research questions (as described in Chapter 1) affirms the conformity of the paradigm as this research is focused on the interactions between the participants and the innovation program (i.e SSIs-based instruction) in a specific context and culture in which they interact. As interpretive investigation pays great attention to the context in which participants share their experiences and a distinct context may imply the diverse meanings of the experience, then theory becomes various sets of meanings which may yield insights and understanding of people's actions according to a relevant situation (Cohen, Manion, & Morrison, 2007). Therefore, by these arguments it is noted that interpretive research is a fundamental basis of research in educational practice (Garrick, 1999).

## 3.2 Research Design

### 3.2.1 Case study strategy

Following the recognition of paradigms as a philosophical basis of the research leads to defining the research design that should align with the paradigm. Case studies, phenomenological, narrative or ethnographic research designs that are mostly preferred by interpretivist researchers are qualitative in nature (Candy, 1989; Cohen et al., 2007; Garrick, 1999; Treagust et al., 2014). Therefore, this research is designed to find out how an innovation in science teaching and learning (i.e SSIs-

based instruction) will be perceived by Indonesian biology teachers as well as their students in the context of their classrooms. Consequently, this research attempts to investigate contemporary phenomena which are likely to occur when the innovation is implemented. In this way, the research is defined as case study research. As Yin (1994) states, "a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13).

Besides featuring a "contemporary"-phenomenon, a case study investigation is also viewed as being "specific" and as a bounded system consisting of a program, an event, a person, a process, a class, or a social group in which case study research in education particularly seeks to understand problems of practice (Merriam, 1990). A case study is a preferred design to answer 'how', 'why' or 'what' questions (Burns, 2000; Yin, 1994) with characteristics to describe real people and to understand their perceptions of what they do in real situations or contexts where behaviours of the participants cannot be manipulated (Yin, 1994) and there is a lack of control over the event or situation (Cohen et al., 2007).

According to Merriam (1990), there are four properties of a case study including: particularistic, descriptive, heuristic, and inductive features. *Particularistic* means that the case study focuses on a particular situation, event, program, or phenomenon. The case itself is important for what it reveals about the phenomenon and for what it might represent. *Descriptive* means that the end product of a case study is a rich, "thick" description of the phenomenon under study. The thick description refers to a complete and literal form of description of the entity being investigated supported with images or analysed situations, instead of reporting findings in numerical data including as many variables as possible that portray their interactions. *Heuristic* means that case studies illuminate the reader's understanding of the phenomenon under study. They can bring about the discovery of new meaning, extend the reader's experiences, or confirm what is known. *Inductive* means that, for the most part, a case study relies on inductive reasoning by which data are grounded in the context itself for interpretation and meaning-making.

Discovery of new relationships, concepts and understandings, rather than verification of predetermined hypotheses, characterizes (qualitative) case studies. How the features of case study research can be translated into practical dimensions relies on five essential components of case study research design (Yin, 1994), including: 1) research questions, 2) propositions, 3) unit of analysis, 4) the logic linking the data to the propositions, and 5) the criteria for interpreting the findings.

Firstly, *research questions* play an important role for defining the research strategy under study. Given the five basic types of questions including "who", "what", "where", "how" and "why", a case study is mostly led by "how" and "why" questions because these types of questions drive a researcher toward "needs-clarification" of problems that might take a long-term process rather than an incidental one (Merriam, 1990; Yin, 1994). However, "what' questions also could fit especially with an exploratory case study as "a justifiable rationale" (Yin, 1994, p.5) and aim to understand a particular situation (Merriam, 1990). Thus, as this research is aimed at understanding teachers' and students' experiences in a SSIs innovation, this research is categorized as an exploratory-descriptive case study (Merriam, 1990).

The second component *propositions* directs attention to something that should be examined within the scope of the study. It helps to capture the researcher's interest and where to look for relevant evidence. Particularly for an exploratory case study (that is driven by a "what" type question), propositions may represent "the criteria by which an exploration will be judged successfully" (Yin, 1994, p.21). For this research, two main areas of propositions include teachers' as well as students' perceptions of SSIs-based instruction and student informal reasoning. Reviews about these propositions are presented in chapter #2.

In a case study, *the unit of analysis* has to be defined to consider the problem that has been identified. Thus, the unit of analysis can be individuals, a program, or a group based on the extent to which the results of the research will be explained and reported (Merriam, 1990). Lastly, the fourth and fifth components – the logic linking the data to the propositions and the criteria for interpreting the findings –

represent the way the data are analysed as well as the interpretations that will be made (Yin, 1994).

### 3.2.2 Research participants

Four biology teachers with various teaching experiences voluntarily participated in this research. Even though it was not intended previously, the teachers have been teaching in different schools from different areas which could represent distinct socio-economic backgrounds. However, all teachers are from the same origin of the Special Province of Yogyakarta, Indonesia. Due to ethical considerations, the names of the participants in this report are pseudonyms.

Mr. Budi, who has been teaching for 17 years, is a biology teacher in a senior high school in the Bantul district. In the same district as Mr. Budi, Mrs. Nur has been teaching for 10 years. From the city of Yogyakarta, Mrs. Dwi has been teaching for 13 years in a senior high school. These three teachers are officially employed by the Department of Education. In comparison to these three teachers, Ms. Aisi is a-less experienced teacher who was not officially employed by the department. However, for this research, Ms. Aisi was permitted to casually teach one grade 10 class each in the same school with Mrs. Dwi and Mrs. Nur. In this research, each teacher taught one class with various numbers of students suggested and approved by the school principal. Detail of the demography of the classes is described in Table 3.1.

Table 3.1. Detail of research participants and SSIs implemented in each class

| Teacher | Class grade | Number of students | SSI being discoursed |
|---|---|---|---|
| Mr. Budi | 11 | 32 | Breastfeeding vs formula milk |
| Mrs. Dwi | 11 | 32 | Mobile phones and society |
| Mrs. Nur | 11 | 31 | Mobile phones and society |
| Ms. Aisi | 10 | 30 | Motorcycle driven by students |
| | 10 | 30 | Hotel development and water sustainability |

### 3.2.3 Context and research frameworks

To affirm how a case study strategy is used in this research it is a necessary to figure out the context and research frameworks, as explained as follows:

1) The "case" in this research is defined as a SSIs-based instruction which was designed and introduced through a teacher professional learning program.
2) The main problem of this research is how teachers as well as students who participated in this research perceived the SSIs-based instruction that was introduced. As it was stated previously in Chapter #1, this problem is represented by three research questions:

   (5) What are Indonesian students' perceptions of SSIs-based learning in biology?

   (6) What types of informal reasoning can be performed by students in SSIs-based learning?

   (7) What are Indonesian biology teachers' perceptions of SSIs teaching practice?

   However, another research question: *"Do students' perceptions of SSIs-learning scales designed for assessing students' perceptions of SSIs-based learning produce a reliable and valid instrument?"* is actually addressed in the development of an instrument for supporting research question #1 above and is discussed separately in Chapter #4.

3) According to these three research questions, the unit of analysis of this case study is "the class" of students for each aspect that encompasses: 1) students' perceptions of SSIs-based learning, 2) students' informal reasoning, and 3) teachers' perceptions of SSIs-based teaching.

4) The teacher professional learning program on SSIs-based instruction, as a "case", follows the 'reflection-in-action' framework (Simon & Campbell, 2012) with a participatory design (Konings, Brand-Gruwel, & van Merrienboer, 2007) because it involves a thinking activity about an event or occasion in which teachers are involved. Furthermore, Konings et al. (2007)

asserted that the participatory design is a stronger approach rather than only informing the innovation to the targeted participants. The approach provides an occasion for teachers to participate in the professional learning program that includes the analysis of the teachers' needs and possibilities, generates the framework and its management, and arranges the implementation of the SSI-based instruction innovation.

5) The teacher professional learning program was conducted in four phases as follows:

***Phase 1: Reflection of teaching experiences and background knowledge***

The first phase of this research was designed to explore teachers' teaching experiences and their background knowledge regarding SSIs. Through a reflection sheet (Appendix B), each participant was asked to describe their teaching experiences of a certain biology topic and the instructional strategy that was employed in teaching the topic. Moreover, they were also asked about their prior knowledge of the social-related topic in biology and whether or not they had experience in teaching about, as well as about scientific literacy and its relevance to biology teaching and learning. During an in-school scheduled occasion, participants were provided an appropriate time to complete the sheets. The written descriptions provided by the participants are useful as a base view of their knowledge.

Following the reflection activity, the researcher provided a plan of the workshop on SSIs-based instruction and discussed with all the participants on the time required, a brief preview about what they would do and developed the schedule for implementation and observations.

***Phase 2: Workshops on SSIs-based teaching***

Three days of professional development workshops were conducted following Phase one. The main objectives of the workshop provided the basic theoretical framework of SSIs and practical teaching aspects for the teachers. With this information, they would be able to develop their

knowledge and basic skills of SSIs-based instruction and consider its viability of being implemented in their classroom. The discussed contents of workshops included: the characteristics and objectives of SSIs-learning, instances of SSIs in Indonesia contexts, and the basic framework of SSIs-based strategy. The developed and implemented workshop is described in Appendix C.

The written reflective journals were collected from each participant in an attempt to obtain data about their understanding of: SSIs and scientific literacy in biology education, the SSIs-based teaching strategy and its implementation in the biology classroom. Besides personal journals, an interview was also conducted to review what each participant had written (including from phase 1) and to look at their thought of factors that may support or impede SSIs-based teaching that need to be considered, and general perceptions of SSIs-teaching preparations.

***Phase 3: The development and implementation of SSIs-based learning materials in biology classrooms***

Following the workshops, the researcher and participants collaborated to develop the SSIs-based teaching materials. Concerning ethical issues, consideration was given to the compliance of the school academic timeframe and curriculum needs. It should be noted that this research was unable to determine one common timeline for implementing the lesson program and teachers chose their own timeline. It means that each teacher has his/her own schedule to implement SSI-based instruction in his/her biology class. The researcher and teachers discussed the potential topics that were available for implementation in the intended time frame that was suggested by each participant.

Regarding the SSIs that were developed, the researcher offered some ideas specific to the Indonesian context to be used during the workshops. A brief description of the issues is outlined in the following Table 3.2. Moreover,

assisted by the researcher, lesson plans for each issue were written by each teacher and individual teachers who implemented the SSIs-based teaching in his/her biology classroom based on the arranged schedules. The sample of learning material for the implementation is presented in Appendix D.

Table 3.2 A brief description of the socio-scientific issues implemented in this research

| Socio-scientific Issue | The Standpoint of the Issue | Discussion Guideline | The scope of biology knowledge |
|---|---|---|---|
| Breastfeeding vs Formula milk: Is a doctor's note required? | Attempts to promote a breastfeeding program by the government in Indonesia may be challenged by infant formula milk products that influence mothers who prefer it as a breastfeeding substitute. To ensure that the breastfeeding program is successful, do you agree that consumers who intend to purchase infant formula milk for their baby are required to have a doctor's note? | Expert panel discussion which involves the role of: local authority district of health, religious affairs authority, group of community/costumers, and formula milk producers. | - The anatomy & physiology of lactations<br>- The characteristic of breastmilk and cow's milk-based formula<br>- Infant feed and brain development |
| Mobile phone and society; Should free wifi be restricted? | Concerning the possible health issues regarding mobile phone usage and wifi facility in our society, do you agree that the free-wifi facility in public spaces needs to be restricted? | Group discussion on pros & cons, the advantages-disadvantages, and challenges that might arise toward the issue | - The anatomy & physiology of hearing<br>- The characteristic of electromagnetic wave frequency<br>- Electromagnetic interference<br>- The specific absorption rate (SAR) & the degree of electromagnetic radiation |
| Motor cycle driven by students; Should it be banned? | Considering one of the most frequent motor cycle drivers in Yogyakarta are school students, do you think that for decreasing the greenhouse effect a regulation from the local government to ban motor cycles driven by students is required? | Group discussion on pros & cons, the advantages-disadvantages, and challenges that might arise toward the issue | - Ecosystem<br>- $CO_2$ emission as a greenhouse gas (GHG)<br>- Greenhouse effect mechanism |
| Hotel development and water sustainability; Should the development be limited? | The rapid development of properties, particularly hotels, in the Yogyakarta region may support the economic sector. However, on the other hand, the development may also impact on the water cycle disruption. To negotiate this issue, do you agree that hotel development in Yogyakarta should be limited? | Expert panel discussion which involves the role of: local government, environmental NGO, property investor, and group of community | - The hydrology cycle & its importance for organisms<br>- Land or groundcover management and natural water sustainability |

It should be noted that based on the research questions, besides the teacher and student activities during the teaching and learning process, informal reasoning was the main learning objective that needed to be examined in each SSIs-based teaching and learning lesson. In this regard, a number of studies on students' informal reasoning have provided various strategies for examining students' informal reasoning (e.g Dawson & Venville, 2009; Sadler & Zeidler, 2005; Wu & Tsai, 2007). However, due to an ethical consideration that the school did not provide any particular occasion for researcher to conduct interviews with all students, this means that, instead of implementing a dialogical strategy (i.e., interviews), another possible way of examining students' informal reasoning skills was through written expressions (Venville & Dawson, 2010) using an informal reasoning sheet. Adopting a work by Chowning et al (2012), the sheet contains an illustration of a SSI and followed by a problematic question that needs to be resolved through a decision (as well as opinion) by student. The sample of informal reasoning sheet is provided in Appendix E.

Consideration was given to students' experiences during their previous learning that may have influenced their individual informal reasoning performance. To gain a deeper view about such skills, an informal reasoning sheet was provided to students before and after the learning process. However, this pre- and post-examining approach was for supporting the behaviour exploration and was not intended to examine the effectiveness of the SSIs-based instruction (i.e. as a treatment) on students' informal reasoning.

***Phase 4: Reflection of post-implementation***

At the end of the teacher professional learning program, an in-depth interview was carried out with each teacher-participant in order to understand his/her experiences as well as perceptions after implementing the SSIs-based teaching practice. A review of teacher knowledge and beliefs

on SSIs-teaching, the advantages and challenges that occurred during the implementation, and views of the possibility for further development, were some aspects that were explored. The interviews were carried out in Indonesian, voice-recorded and acknowledged by the participants.

## 3.3 Data Collection Methods

According to Cohen et al., (2007) selecting information is a key issue that needs to be considered in case study research. Further, these authors also assert that besides being aligned with common patterns of data recording that includes frequently typical and representative emergence categories, research through case study requires a strong awareness of critical incidents or events which might be crucial toward understanding of the case. Even though data gathering in a case study design mostly relies on a qualitative approach (Merriam, 1990), it is possible to use a combination of both quantitative and qualitative data sources (Burns, 2000).

The previous section (Section 3.2.3 Context and framework of the research), indicated the intended data and the ways that those data were collected. Yin (1994) specifically stated six sources by which data can be obtained in a case study which included documents, archival records, interviews, direct observations, participant-observations and physical artefacts. Thus, the following section provides basic descriptions about some methods which were used in the data collection process of this research and is summarized in Table 3.3.

Table 3.3. Data collection methods for each of phase of the research

| Phase | Main Activity | Data | Data collection methods |
|---|---|---|---|
| **Phase #1** | *Reflection of teaching experience and the background knowledge* | 1) Teachers' teaching experience<br>2) Teachers' SSI-background knowledge | 1) Reflection sheets<br>2) Interviews |
| **Phase #2** | *Workshops on SSI-based teaching* | Teachers' knowledge on SSI-based instruction | 1) Personal journal<br>2) Interviews |
| **Phase #3** | *The development and implementation of SSI-based learning materials in biology classrooms* | 1) Teachers' roles on SSI-based teaching practice<br>2) Students' activities during SSI-based learning<br>3) Students' informal reasoning | 1) Observations<br>2) Interviews<br>3) Student perceptions questionnaire<br>4) Student worksheet<br>5) Informal reasoning sheet |
| **Phase #4** | *Reflection of post-implementation* | 1) Teachers' perception of SSI-based teaching practice<br>2) Students' perception of SSI-based learning | Interviews |

### 3.3.1 Interviews

In a case study, the interview is one of the most important sources of data because this kind of research is about human affairs which should be viewed through interactions with the respondents (Yin, 1994). The importance of interviews is also viewed by Merriam (1990) because the researcher is not always able to "observe behaviour, feelings, or how people interpret the world around them" (p.72).

The way a researcher can obtain case study data from interviews is based on the preference of the strategy by which the interview is arranged. Yin (1994) described three types of interview forms. Firstly, an open-ended interview allows the researcher to ask respondents' opinions about events, facts, or even to propose his own or her own insights into certain occurrences. The second type is a focused interview which is usually preferred due to limited time and is driven by a set of questions even though the researcher may still follow a modified open-ended strategy. The last type is represented by fully structured questions.

Due to ethical considerations, particularly the limited time provided by the school, the second type of interviews with a semi-structured set of questions was used in this research. I argue this second type of interview is appropriate for this research. Because, on one hand, the set of questions lead the researcher focus on the priority data that need to be obtained. On the other hand, it may also allow the researcher to ask additional questions that could be relevant as well as important in following up the experience or opinion expressed by the participants, within a fully consideration on limited time provided. This interview protocol is provided as Appendix F & G.

### 3.3.2 Written Documents

According to Yin (1994), the use of paper-based data can be used as documentation or archival records. Documentation may include letters, memos, agenda, administrative documents, formal studies or evaluations of the 'site', and newspaper clippings. An important feature of documentary information is "it should not be accepted as literal recording of events that have taken place" and its function is "to corroborate and augment evidence from other sources" (p.81). In different forms, such as service or organizational records, maps or charts, survey data, and personal records, the usefulness of archival records in case study research may vary. What needs to be considered by the researcher who is willing to use this type of paper-based information is the condition under which the records were produced to ensure their accuracy; most archival records are produced for a specific purpose as well as a particular audience. Therefore, written documents in this research refer to any information provided by the participants about a specific issue or task and function that is written down. These kinds of data sources are recognised as documentation including teacher reflection sheets and personal journals, student questionnaire and informal reasoning sheet, and student working sheet.

### 3.3.3 Observations

A typical method of data gathering in case study research is observation of an individual unit – a student or a class – which is distinguished into two types: participant and non-participant observation (Cohen et al., 2007). The former type indicates the active involvement of the observer in every activity undertaken in which the case study is conducted and where there is an intention to have interaction with the participants. Distinct from participant observation, the non-participant observer usually stays alone himself/herself on a seat at the back of the class making notes without having any interactions with the participants. According to Yin (1994), observations can be distinguished into two modes: direct and participant-observation. When a researcher visits a site where a case study is undertaken and observes events such as a meeting or classroom activities, this involves direct observation. Unlike direct observation, participant-observation is a special mode in which a researcher does not stand as a passive observer, rather he or she may have a particular role and actually participates in the case study.

However, based on my experiences involved in science education research in Indonesia, I consider that sometimes students tend to make a conversation with the observer. The conversation commonly arises when students are asking for an explanation, or even answer for the learning task provided by their teacher which they need to complete. Thus, instead of a natural situation where the interaction between student and student or student and teacher that is intended to appear during the lesson, the conversation, according to Yin (1994), may lead to potential biases related to the student behaviour which needs to be observed. To avoid such biases as well as keeping the objectivity of the observation, I decided that it is better to use direct observations instead of participant-observation.

### 3.3.4 Student Perception Questionnaire

The questionnaire used in this study is particularly for collecting the data of student perceptions of SSI-based learning which is dealing with research question #1 and #2. The development of this questionnaire specifically is described in Chapter #4.

## 3.4 Data Analysis

### 3.4.1 Basic frameworks of analysis

A special feature of a case study is that there is no certain and specific formulae for data analysis so the researcher needs to plan and decide to what extent the data will be analysed; this data analysis plan is the primary issue that needs to be considered (Burns, 2000). According to Yin (1994), defining the basic strategy is essentially needed for the first process of data analysis in a case study because it will assist the researcher to manage the data and generate a clear map of interpretation toward making conclusions. Thus, following Yin's suggestion, the basic framework of analysis that underpins this research includes defining the general strategy of analysis as well as the specific analytic mode and follow up with cross-case analysis.

For the general strategy, this research relies on selected theoretical propositions that were reviewed and guided this research (Burns, 2000). However, it should be reminded that the propositions are not hypotheses but rather criteria that allow the researcher to focus on certain relevant data and may ignore irrelevant ones (Yin, 1994). Following this general strategy, an *explanation-building mode* was used as the specific analytic method for this research which seeks to explain the investigated phenomena.

### 3.4.2 Cross-case analysis

The basic reason why a cross-case analysis is valuable in this research is that it allows the researcher to further examine the data across the cases and gain a deeper insight and understanding of the results (Miles & Huberman, 1994). Unlike a *case-oriented* strategy that focuses on examining each case about the expected pattern based on a theoretical framework and defines where the pattern is matched or mismatched, *variable-oriented* strategy is used in this research because it is possible for the researcher to look for *themes* or *patterns* of the data across the cases based on propositions.

In alignment with the basic framework above, the phases of the explanation-building in this research included defining the unit of analysis (i.e., teachers' and students' statements or answer from each class), organizing the data topically and chronologically, identifying the patterns of the unit of analysis, and interpreting the pattern of data based on defined dimensions or propositions from reviews of the literature (Merriam, 1990). Thus, these frameworks were used to obtain data about teachers' and students' perceptions of SSIs-based instruction. However, different dimensions or propositions were used for interpreting each data of the teachers' and students' perceptions. Four dimensions of perceptions were used for the analysis of the teachers' data about their perceptions, including: knowledge of SSIs & scientific literacy, the necessity of SSIs in the biology classroom, factors influencing SSIs-teaching, and teacher beliefs. For data about students' perceptions, four dimensions were used, including: contextualisation of SSIs, SSIs-learning objectives, attitude toward SSIs-learning, and involvement in SSIs-learning.

### 3.4.3 Student Informal Reasoning

Distinct from the analysis of students' and teachers' perceptions, a specific analysis strategy for students' informal reasoning was used. As students were asked to express their arguments in written form (both during the pre- and post-instruction), it was not possible for them to provide a verbal rebuttal in their argument (Venville & Dawson, 2010). Thus, the written statements provided by each student to the issue were the unit of analysis.

A qualitative analysis approach was applied in this research to determine the characteristics or patterns of the informal reasoning generated by students which is mainly based on the framework developed by Sadler and Zeidler (2005). The framework explains that informal reasoning stated by each student could be classified as *rationalistic, emotive, intuitive,* or a combination of these patterns. Although students may involve various considerations toward the SSIs being discussed such as side effects or issues of interest, *rationalistic* informal reasoning typically is expressed solely on reason and logic to formulate and support the

students' positions. In some instances, students may respond to the issue with *intuitive* informal reasoning mainly based on their immediate feelings or reactions either positively or negatively, and these contribute to the eventual resolution of the issue. Furthermore, some informal reasoning expressed by students could be related to the moral emotions, empathy and sympathy, that represent a sense of care toward the others who might affect any decisions made. Thus, this reasoning is termed *emotive* informal reasoning. These categories were exemplified by Dawson and Venville (2009) in their research with a description as presented in Table 3.4. Furthermore, it should be noted that based on their research, Sadler and Zeidler (2005) showed the integrating of multiple patterns of informal reasoning expressed by students which means that the expression of informal reasoning may not be a single-based pattern, but also potentially can be a combination of each pattern.

Table 3.4. Category and description of informal reasoning patterns

| Category | Description |
|---|---|
| Rationalistic | Logical, uses scientific understanding and language, weighs up risks and benefit, advantages and disadvantages. |
| Emotive | Emotional response towards stakeholders, care, empathy, sympathy, concern for plight of those affected. |
| Intuitive | Gut feeling. Immediate response, strongly held, often a negative response, personal, often precedes rational or emotive. |

(Dawson and Venville, 2009).

Furthermore, to categorise students' informal reasoning data in the described patterns, deductive content analysis strategy was used in which all the data were reviewed for content and coded for correspondence to or exemplification of the identified categories (Elo et al., 2014; Elo & Kyngäs, 2008). This strategy starts with making a categorization matrix followed with coding the data according to the categories descried before (Elo & Kyngäs, 2008). To summarise the categorised patterns of the data, the researcher reread and recoded the data on three occasions within a certain interval time (approximately one to two weeks within each of the activities). The results of the analysis then represented and described correspondence to the pattern of informal reasoning, supported with quotes from the data set.

## 3.5 Quality Standard

Quality standard which is generally termed as validity in interpretive research is an absolute need as "there is a general consensus that qualitative inquirers need to demonstrate that their studies are credible" (Creswell & Miller, 2000, p. 124). The necessity of assessing validity (as well as reliability) particularly for case studies in education was also suggested by Merriam (1990). Regarding this consideration, Creswell and Miller (2000) suggested that the lens in which researchers validate their research and the research paradigm may underpin the choice of validity procedures. Unlike quantitative research which builds inferences based on scores from instruments, qualitative researches mostly use the view of people who conduct, participate in, or those who read and review the study. Besides, these lenses used by the researcher could also shape the selection of validity procedures. Especially for the interpretive paradigm which underpins this research, trustworthiness and authenticity are the main criteria of the validity standard. Instead of viewing those perspectives in a dichotomous way, Creswell and Miller (2000) developed a framework of validity procedures in a two-dimensional view within both lenses and paradigms. Based on Table 3.5, disconfirming evidence, prolonged engagement in the field, and rich descriptions are three procedures for quality standards in interpretive research that were used in this research.

Table 3. 5. Validity procedures within qualitative lens and paradigm assumptions

| **Lens & Paradigm Assumptions** | **Post-positivist** | **Constructivist or Interpretive** | **Critical theory** |
|---|---|---|---|
| Lens of the researcher | Triangulation | Disconfirming evidence | Researcher reflexivity |
| Lens of participants | Member checking | Prolonged engagement in the field of study | Collaboration |
| Lens of readers or reviewers | The audit trail | Thick and rich description | Peer debriefing |

(Creswell & Miller, 2000).

Relying on the researcher's own lens, disconfirming the evidence drives the researcher to examine the data and determine whether or not the evidence is consistent with or disconfirms the themes or categories which were originally developed and reviewed. However, the adequacy of evidence could be obtained by being in the field of research over a period of time. Although there is no certain time duration, it should be considered that prolonged engagement in the field enables the researcher to interact with participants more intensely, making them more comfortable with his presence and hence disclosing more information. This approach implies that thick and rich descriptions of information could be revealed. By the rich descriptions provided, the researcher may lead the readers or reviewers to feel the situation to be real as well as to have the same experience as the participants who are involved in the study. Thus, "credibility is established through the lens of readers who read a narrative account and are transported into a setting or situation" (Creswell & Miller, 2000, p.129).

Although it is shown in Table 3.4 that member checking is not necessarily a part of the validity procedure for interpretive research, however, member checking provides a valuable function for the quality standard of qualitative research including case studies (Merriam, 1990). Member checking allows the researcher to give the data and interpretations back to the participants in an attempt to find confirmation about the credibility of the information from the participants (Creswell & Miller, 2000; Merriam, 1990). By the member checking method, the researcher is using the lens of participants to ensure that the data are credible and realistic. Especially for this research, the member checking process undertaken was to ask the participants to review and read the transcriptions of interviews, informal reasoning answers, as well as the observation notes, and to provide comments. Furthermore, the researcher incorporated participants' comments into the final narrative.

# CHAPTER 4

# DEVELOPMENT OF AN INSTRUMENT FOR ASSESSING STUDENTS' PERCEPTIONS OF SOCIO-SCIENTIFIC ISSUES-BASED INSTRUCTION IN BIOLOGY

## 4.1 Overview

This chapter specifically presents the development of the instrument that was used to obtain the data regarding students' perceptions of socio-scientific issue (SSI)-based instruction in secondary classrooms in Indonesia. As mentioned in Chapter 3, the development of the instrument described in this chapter is used to address the research question: *"What are Indonesian students' perceptions of SSI-based learning in biology?"*

This chapter encompasses four elements. First, it discusses the theoretical framework that underpins the instrument development. Following this, the methodology of the instrument development is illustrated in the second part. Data obtained from the pilot study and the meaning of the usefulness of the instrument for further application are each further elaborated in parts three and four.

## 4.2 Theoretical Basis of the Instrument Development

Reviewing instruments that were employed for investigating students' perceptions of SSI implementation in previous studies (e.g Eastwood, Schlegel, & Cook, 2011; Feierabend & Eilks, 2010; Ottander & Ekborg, 2012; Topcu, 2010) shows that these were not entirely suitable for further research in secondary classrooms in Indonesia. For example, one of the instruments developed by Ottander and Ekborg (2012) explored in-depth students' experiences. However, as this instrument measures

students' characteristics in general science learning instead of in SSIs topics, it is assumed that what students perceived was not directly associated with SSIs-based learning. On the other hand, the instrument used by Feierabend and Eilks (2010) requires further adaptation as it was developed for chemistry lesson instead of SSIs-based instruction in biology. The ATSIS (Topcu, 2010) is also viewed as not suitable because it assesses only attitude towards SSIs rather than SSIs-based learning and was specifically developed for undergraduate students. Thus, this research study considers the need for an instrument for investigating students' perceptions of SSI-based learning specifically in the biology classroom.

Developing an instrument for secondary students' perceptions of SSIs-based learning in this study begins with an in-depth critical review of the pedagogical framework of SSIs in science learning. The review of the literature which is described in the Chapter #2 section 2.2.1, has led to identification of the SSIs-based learning aspects which, in regard to the instrument development, are described in four scales of the questionnaire. These are namely contextualisation of SSIs, student involvement, attitude toward SSIs learning, and SSIs learning objectives. Figure 4.1 represents the relationship between the epistemological framework of SSIs learning and the scales of the questionnaire that were developed in this study.

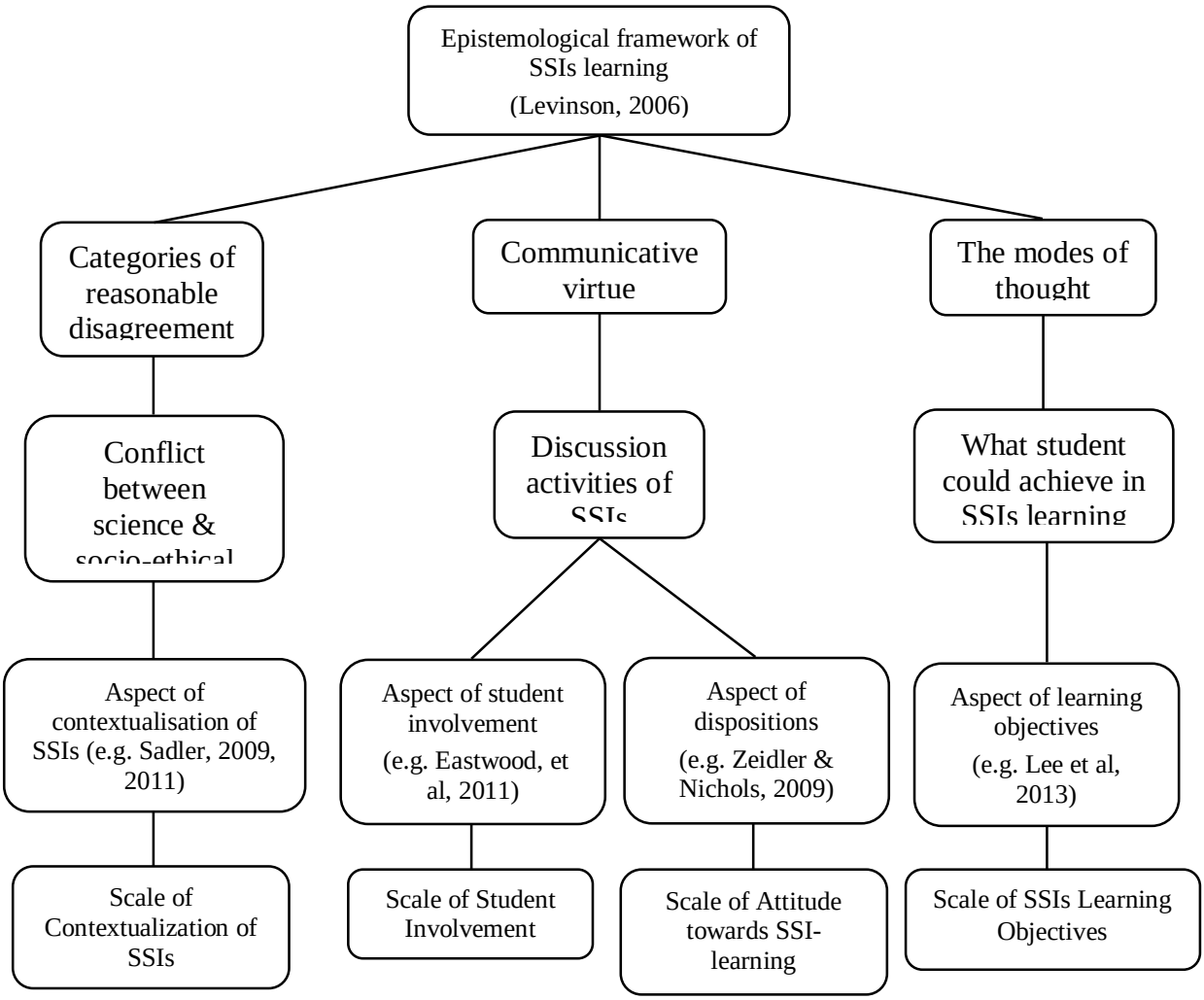



Figure 4.1. Relationship between epistemological framework of SSIs learning and the scales of the questionnaire

## 4.3 Methodology

According to Trochim and Donnelly (2006), validation of a new instrument (i.e. questionnaire) could be examined to its construct validity, which comprises translation validity and criterion validity. Translation validity involves: 1) content validity that reflects on how well-developed the construct underpinned to the theoretical grounds, and 2) face validity which reflects on how easy the items of a construct could be interpreted. Complementary to the translation validity, criterion

validity represents the degree of correlation amongst items of the constructs, which can be distinguished into convergent validity and discriminant validity. Convergent validity is shown if items of a construct have strong correlation to each other. In contrary, discriminant validity will obviously be occurred when items from different constructs are not highly correlated to each other.

Toward the framework of validity above, this study utilised both qualitative and quantitative approaches in a research design involving four phases. The first phase, based on the theoretical framework that was established, involved analysis and construction of the items for the defined scales. As noted in the earlier part of this chapter, the existing instruments were not considered suitable for evaluating the teaching of SSIs-based topics in Indonesian secondary school biology lesson. Consequently, a new instrument was developed based on the authors' knowledge of previous research. In an attempt to obtain reliable items, this study adopted some items from existing instruments, including the scale of learning about the world from the Constructivist Learning Environment Survey (CLES) (Johnson & McClure, 2004), the scale of involvement from the What Is Happening In this Class? (WIHIC) instrument (MacLeod & Fraser, 2010), and the scale of adoption of scientific attitudes from Test of Science-Related Attitudes (TOSRA) questionnaire developed by Fraser (1981). Items for the scale of the SSIs learning objectives were constructed by the authors. A five response Likert-type scale was used to measure students' responses ranging from Strongly disagree (scale of 1), Disagree (scale of 2), Not sure (scale of 3), Agree (scale of 4), to Strongly agree (scale of 5). For the four scales which were defined, seven items were constructed for each scale and were reviewed for their language conformity. As some items were adopted from established instruments, only a few revisions were carried out to adjust the context of the SSIs lessons for each scale. Table 4.1 represents the scales and their items.

Table 4.1. Scales and items of developed instrument

| Scale & source(s) | Items |
|---|---|
| Contextualization of SSIs (CLES; Johnson & McClure, 2004) | 1) I learn about biology outside of school (C1)<br>2) What I learn starts with issues related to biology in daily life (C2)<br>3) I learn how biology can be part of my out-of-school life (C3)<br>4) I get a better understanding of biology in daily life (C4)<br>5) I learn interesting things about biology outside of school (C5)<br>6) I realize that biology is relevant to my life (C6)<br>7) I find real examples of the relationship between biology and daily life problems (C7) |
| Attitude towards SSIs-learning (TOSRA; Fraser, 1981) | 1) I am asked to explain how I solve the issue (A1)<br>2) I enjoy discussing about things which disagree with my previous ideas (A2)<br>3) I am curious about biological issues that are debated in society (A3)<br>4) Finding out about new things concerning biology is important (A4)<br>5) I like to listen to people whose opinions are different from mine (A5)<br>6) I find it is challenging to know about new ideas (A6)<br>7) I am willing to change my ideas when evidence shows that my ideas are poor (A7) |
| Student Involvement (WIHIC; MacLeod & Fraser, 2010) | 1) I discuss ideas in class (I1)<br>2) I give my opinion during class discussions (I2)<br>3) Other students listen carefully to my ideas (I3)<br>4) My ideas and suggestions are used during classroom discussions (I4)<br>5) I ask other students to explain their ideas (I5)<br>6) I explain my ideas to other students (I6)<br>7) Other students discuss with me how to go about solving the issue (I7) |
| SSIs Learning objectives (Developed by authors) | 1) I learn how to select appropriate scientific-based information (LO1)<br>2) I learn social values that are related to biology (LO2)<br>3) I learn how to apply my biological knowledge to respond to others' opinions (LO3)<br>4) I learn how to make an adequate argument to discuss biological issues in daily life (LO4)<br>5) I learn how to make good decisions (LO5)<br>6) I learn how to be concerned about ethics to solve biological issues that arise in society (LO6)<br>7) I learn how to think about various aspects to solve social problems that are related to biology (LO7) |

Following the first phase, the proposed items were first written in English and validated by two proficient researchers of science education. Further, the items were translated into Bahasa Indonesia and reviewed for language conformity by two bilingual (English and Bahasa Indonesia) experts. Two experienced biology teachers also reviewed the items to verify item clarity. After this review, the items were back-translated into English without reference to the original version. The meaning of the back-translation was checked or compared with the original version to decide whether or not any items needed revision (Velayutham, Aldridge, & Fraser, 2011). The draft of the 28-item instrument (in Bahasa Indonesia) was administered in the pilot study which involved 284 grades 10 and 11 students of both genders from senior high schools in Central Java, Indonesia. The responses were then analysed using factor analysis to explore the structure of the instrument and the internal consistency reliability of each scale was determined using the Cronbach's alpha coefficient.

As the fourth phase of the instrument development, to cross-validate and review the functionality of the developed instrument, the adjusted items based on the results of the pilot study further administered in biology classrooms which implemented SSI-based learning. Data from 151 students who participated in the SSI-based learning further analysed using confirmatory factor analysis (CFA) (Pallant, 2010).

## 4.4 Results

Data from the administration in the pilot study were analysed using SPSS version 20 (Pallant, 2010). First, the initial measurement of the Kaiser-Maiyer-Olkin value of adequacy was found to be 0.872, confirming the appropriateness of the data for further analysis. Following this indication, principal component analysis was carried out with varimax rotation (Pallant, 2010). Based on the factor loading results, four items were removed from three scales because they did not load in the same factor. These included the scale of attitude toward SSIs (item A1: *I am asked to explain how I solve the issue,* and A3: *I am curious about biological issues that are debated in society*), the scale of student involvement (item I7: *Other students*

*discuss with me how to go about solving the issue*), and the scale of SSIs-learning objectives (item LO1: *I learn how to select appropriate scientific-based information*). Table 4.2 summarises the results of the analysis for the rest of the 24 items. Furthermore, the Cronbach's alpha coefficient was calculated for each factor to indicate its internal consistency reliability. The alpha values should be at least 0.70 or higher for Likert-type responses (Pallant, 2010). Hence, each scale was found to have good reliability since the Cronbach's alpha coefficients were above 0.70 for each scale as shown in Table 4.3.

Based on the results of the pilot study above, the 24 developed items further administered into five biology classrooms which implemented various SSI-based learning and involved 151 students. These students' responses were then analysed using confirmatory factor analysis (CFA) (Pallant, 2010). As shown in the table 4.4, the Kaiser-Maiyer-Olkin value as an initial measurement was found to be 0.911, which is confirming the appropriateness of the data for further analysis. Following this indication, principal axis factoring as well as the Cronbach's alpha coefficient calculation for each scale of instrument were carried out and the results are represented in the table 4.5 and 4.6.

Table 4.2. Factor loadings, eigenvalues, and percentage of variance for the questionnaire

| Item | Factors | | | |
|---|---|---|---|---|
| | Contextualisation of SSIs | Learning objectives | Attitude toward SSIs-learning | Student Involvement |
| C1 | 0.63 | | | |
| C2 | 0.50 | | | |
| C3 | 0.57 | | | |
| C4 | 0.64 | | | |
| C5 | 0.60 | | | |
| C6 | 0.68 | | | |
| C7 | 0.56 | | | |
| LO2 | | 0.52 | | |
| LO3 | | 0.63 | | |
| LO4 | | 0.72 | | |
| LO5 | | 0.51 | | |
| LO6 | | 0.61 | | |
| LO7 | | 0.66 | | |
| A2 | | | 0.46 | |
| A4 | | | 0.64 | |
| A5 | | | 0.62 | |
| A6 | | | 0.51 | |
| A7 | | | 0.67 | |
| I1 | | | | 0.57 |
| I2 | | | | 0.69 |
| I3 | | | | 0.68 |
| I4 | | | | 0.70 |
| I5 | | | | 0.55 |
| I6 | | | | 0.54 |
| Eigenvalues | 6.40 | 1.93 | 1.49 | 1.32 |
| % of Variance | 26.67 | 8.04 | 6.20 | 5.51 |
| Cumulative % of variance | 26.67 | 34.71 | 40.90 | 46.41 |

Table 4.3. Internal consistency reliability (Cronbach's alpha) of the questionnaire

| Scale | Number of items | Cronbach's alpha reliability |
|---|---|---|
| Contextualisation of SSIs | 7 | 0.76 |
| Learning objectives | 6 | 0.78 |
| Attitude toward SSIs-learning | 5 | 0.72 |
| Student involvement | 6 | 0.73 |

Table 4.4 KMO and Bartlett's test values of the Confirmatory Factor Analysis

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .911 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 1799.311 |
| | df | 276 |
| | Sig. | .000 |

Table 4.5 Factor loadings, eigenvalues, and percentage of variance for the instrument based on the confirmatory factor analysis

| Item | Factors | | | |
|---|---|---|---|---|
| | Contextualisation of SSIs | Learning objectives | Attitude toward SSIs-learning | Student Involvement |
| C1 | 0.53 | | | |
| C2 | 0.64 | | | |
| C3 | 0.61 | | | |
| C4 | 0.65 | | | |
| C5 | 0.62 | | | |
| C6 | 0.48 | | | |
| C7 | 0.61 | | | |
| LO2 | | 0.57 | | |
| LO3 | | 0.68 | | |
| LO4 | | 0.67 | | |
| LO5 | | 0.62 | | |
| LO6 | | 0.71 | | |
| LO7 | | 0.75 | | |
| A2 | | | 0.67 | |
| A4 | | | 0.56 | |
| A5 | | | 0.51 | |
| A6 | | | 0.55 | |
| A7 | | | 0.46 | |
| I1 | | | | 0.66 |
| I2 | | | | 0.66 |
| I3 | | | | 0.69 |
| I4 | | | | 0.63 |
| I5 | | | | 0.58 |
| I6 | | | | 0.55 |
| Eigenvalues | 9.58 | 1.90 | 1.38 | 1.14 |
| % of Variance | 39.93 | 7.92 | 5.73 | 4.75 |
| Cumulative % of variance | 39.93 | 47.84 | 53.58 | 58.32 |

Table 4.6. Internal consistency reliability (Cronbach's alpha) of the final instrument

| Scale | Number of items | Cronbach's alpha reliability |
|---|---|---|
| Contextualisation of SSIs | 7 | 0.83 |
| Learning objectives | 6 | 0.86 |
| Attitude toward SSIs-learning | 5 | 0.75 |
| Student involvement | 6 | 0.87 |

Based on table 4.5, it is indicated that all items loaded above 0.40 (with the lowest being 0.46 for item A7) on their respective factor and did not load on any other factor. Moreover, the loading factors show how well each item is related to a particular factor, and, on the other hand, items in one factor are definitely distinguished to different factors. Dealing with the eigenvalues, each factor gained greater than 1 and the variance for all factors cumulatively at modest level (58.3%).

## 4.5 Discussion

The main purpose of this study was to develop an instrument that would help teachers to gain an understanding how their students perceived SSIs-based learning that they have experienced in biology classes in lower secondary science in Indonesia. A few studies have involved students' experiences (e.g., Eastwood et al., 2011; Feierabend & Eilks, 2010; Ottander & Ekborg, 2012; Topcu, 2010); however, no relevant instrument has been developed in biology lesson.

Trying to comprehensively accommodate the fundamental principles of SSIs and their practices in science classes, an extensive literature review of this study led to four scales of the questionnaire defined as contextualisation of SSIs, attitude toward SSIs learning, student involvement and SSIs learning objectives, as represented by the figure 4.1. These four scales, which reflect the cognitive as well as affective dimensions experienced by students in SSIs-based learning, established that the items were well conceptualised toward the theoretical grounds. Moreover, it is also

authenticated that during the second and the third phase of the instrument development – where involved proficient researchers on science education, bilingual experts, and experienced biology teachers – the items could obtain the best representation of the constructs and easily understood. Thus, the developed instrument qualitatively meets the content and face validity.

Quantitative results of the administration of the instrument, on the other hand, support the qualitative findings above. According to the factor loadings, either based on the pilot study (i.e. table 4.2) as well as the confirmatory factor analysis (i.e. table 4.5), it is clearly showed that the items can be extracted into four concise scales where each scale definitely examines different dimension. Furthermore, the Cronbach's alpha reliability generated from both analysis (exploratory and confirmatory factor analysis) also represents a good internal consistency measurement by the items. Thereby, these quantitative results conform the convergent as well as discriminant validity of the developed instrument.

Reviewing the appropriateness of the developed scales and their items, it is important to gain an understanding of how well they fit the SSIs learning situations which are depicted in various SSIs classroom research studies. The work of Presley et al. (2013) provides a useful framework to obtain this view. Different from Levinson (2006), Presley and his colleagues developed their framework based on SSIs studies reported in a book titled *Socio-scientific issues in the Classroom; Teaching, Learning and Research* (edited by Sadler, 2011). The framework is composed of aspects including *Design elements, Learner experiences, Teacher attributes, Classroom environment,* and *Peripheral influences.*

*Design elements* refer to the need for an issue which is based on society and is strongly connected to science. It should be noted that the issue has an important role not only for providing a controversial problem presented at the beginning of the lesson, but also offering opportunities for students to scaffold their higher order thinking and related skills such as argumentation and decision making during a SSIs-based lesson. Therefore, before it is learnt by students, the issue needs to be well-defined, arranged and constructed into learning scenarios and should provide

contextual conflict in which students will be engaged with. This consideration of providing the issue toward SSIs-based learning is strongly reflected in a number of research studies (e.g Ekborg, Ideland, & Malmberg, 2009; Feierabend & Eilks, 2010; Lee & Grace, 2010; Levine Rose & Calabrese-Barton, 2012). The principle of *design elements*, thus, is aligned with the view of contextualisation of SSIs (Sadler, 2009, 2011) that is represented by seven items in the first scale of the instrument in this study.

Since the aspect of *design elements* emphasizes the role of the SSIs in providing context-based problems that promote the development of the above-mentioned skills, learning experiences during the SSIs-based instruction also need to be considered that will support the achievement of the expected learning objectives. Engaging students in multi-perspectives reasoning, argumentation, as well as dealing with the confrontation between science knowledge (including scientific data) and related social dimensions, are experiences that are required for student in SSIs-based learning. Along with *the learner experiences* aspect, it is necessary that the *classroom environment* is arranged to support students when dealing with their experiences during the SSIs-based lessons. For this purpose, Presley et al. defined some key elements of SSI classroom environment such as providing a supportive challenge for participating in the lesson, a well-designed interaction in which students can interact collaboratively in an interactive way in a fully respected situation.

It is clear that studies on SSIs-based instruction reviewed by Presley and his colleagues reflect the need to consider the SSIs-learning objectives and the affective dimension that represents students' attitudes as well as their involvement during SSIs-based lessons. Therefore, each of the scales of learning objectives, attitude toward SSI-based learning and student involvement which were included in the questionnaire in this study may enable students to perceive these aspects during SSIs-based learning.

Of the five aspects which comprised the framework suggested by Presley et al (2013), the aspects of *Teacher attributes* and *Peripheral influences* are not

explicitly presented in the developed instrument described above and perhaps this is a limitation of this study. However, as the basic idea of the development of the entire instrument in this research was to provide a suitable questionnaire for examining students' perceptions of SSIs-based learning, particularly about the learning situations designed by teachers that they might have experienced, some items included in its scales may accommodate these aspects implicitly. For example, the degree of a teacher's knowledge about the science content related to the issue, or awareness of the social considerations associated with the issue (as the part of the indicators of teacher attributes) could be represented by the functionality of the issue provided. Therefore, this aspect could possibly be perceived through items in the scale of contextualization of SSIs, likewise the indicator of the existence and awareness of local community issues to prompt the SSIs-topic of related aspects. Hence, the four scales of the developed instrument are likely to appropriately accommodate the integrated aspects of the SSIs-based learning required.

To sum up, this study has produced a valid and reliable instrument to assess students' perceptions of SSIs-based learning, referred to as the Students' Perceptions of the SSIs-based Instruction Scale in Biology. The 24 items of the questionnaire make up a comprehensive dimension of the learning environment that might be perceived by students when they experience SSIs-based learning. As this study was developed based on the framework of contextualization of science education in Indonesia particularly for SSIs-based learning in biology classrooms, further research is required to establish the usefulness and re-validation of the instrument in a broader science education context.

# CHAPTER 5

# STUDENTS' PERCEPTIONS OF SSI-BASED LEARNING

## 5.1 Overview

This chapter presents the data and discussions in response to research question #2 which focused on students' perception of SSI-based instructions that were implemented in this research. The research question was: *"What are Indonesian students' perceptions of SSI-based learning in biology?"*.

According to the research method described in Chapter #3, this research study is designed and implemented as a case study; three methods of data gathering were used including questionnaire based, interviews, and class observations. It should be noticed that the unit of analysis of this research is each class of students who participated in this research. An explanation-building mode was applied as the specific analytic method in order to explain the investigated phenomena from each unit of analysis (i.e each class of participant) and followed by cross-case analysis that was used to interpret the data from all classes of students.

This chapter consists of two parts. The first part, Section 5.2, elaborates the data of students' experiences and perceptions of SSI-based lesson that were collected through those three methods of data collection and analysed within the aforementioned framework. Furthermore, the following outline was arranged to make this section readable:

1) Data representation is based on a socio-scientific issue that was implemented with each class of students (as a unit of case study) as is firstly mentioned in a sub-section. Thus, there are four main sub-sections that precede the first section.
2) For each unit analysis, data of students' perception that were gathered from questionnaire are analysed and presented first. Then, interviews as well as

observations findings are presented to elaborate the questionnaire-based results to provide an insightful interpretation.

3) Either part of the interviews or students' statements recorded from class observation are presented or mentioned in this section and are marked with a code. The code consists of: 1) initial of the issue (i.e BFM: Breastfeeding vs formula milk; MpS: Mobile phone and society; HDW: Hotel development and water resources; and McDS: Motorcycle driven by students) added with a serial code, 2) student identity, and 3) sequence number of the quotations.

   For example, the '*quote BFM I-Wh-(1)*' means that this is the first quote expressed by student 'Wh', a student who participated in a SSI-lesson about Breastfeeding vs formula milk. Moreover, the quote is written in the set-I of the excerpts.

4) Codes are also used for marking the quotations with initials used in an excerpt of interview set. The initials are: 1) 'R' refers to the researcher who gave the questions, and 2) the other initial which represents student identity such as 'Wh', 'Lrs', or even just 'A' and 'B'.

The second part of the chapter, Section 5.6, provides a discussion of the research regarding students' perceptions of SSI-based instruction based on the research findings provided in the first section. Unlike the first section which elaborates the research findings based on each issue as well as the class of the student, this second section makes a cross-interpretation on all issues and the unit of analysis (i.e classes of student) in order to construct a comprehensive meaning of students' perceptions of SSI-based instruction corresponding to the research question.

## 5.2 Students' Experience and Perceptions of a SSI-based Learning on Issue #1: Breastfeed vs formula; Grade 11 SMAN 2 Bantul

A review of the trends of the mean values of each perception scale, as represented by Figure 5.1, revealed that students tend to perceive their prior learning experience as meaningful because the mean values particularly for both scales of contextualization of SSI ('Cont') and attitude toward SSI-learning ('Att') were reached a bit more than four (i.e scale for 'Agree' of the instrument) before the SSI-lesson. Unlike these scales, the scale of SSI-learning objectives and the scale of involvement were perceived slightly differently as their mean values were less than four before the SSI-instruction. However, Figure 5.1 shows the positive changes of students' perceptions of SSI-based instruction by which the mean values for each perception increased after the SSI lessons. This trend of positive change is supported by the results of the paired t-test that shows a significant difference ($p<.05$) of mean values of perceptions before and after the SSI instruction for each scale as represented by Table 5.1.

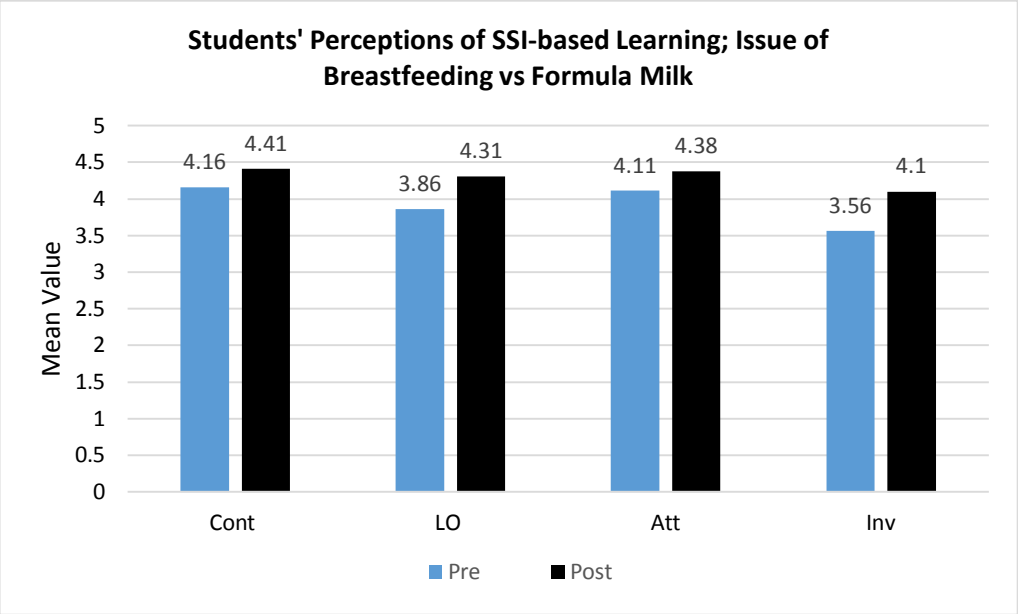



Figure 5.1 Student' perceptions of SSI-based learning on the issue of breastfeeding vs formula milk, from a grade-11 student of SMAN 2 Bantul.

Table 5.1 Paired t-test of mean value for each scale of perception of SSI-based learning on issue of Breastmilk vs Formula milk before and after the instruction.

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Dev | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | PreC - PosC | -.31 | .17 | .03 | -.37 | -.24 | -9.91 | 30 | .00 |
| Pair 2 | PreLO - PosLO | -.42 | .35 | .06 | -.55 | -.29 | -6.59 | 30 | .00 |
| Pair 3 | PreAt - PosAt | -.28 | .26 | .05 | -.37 | -.18 | -5.90 | 30 | .00 |
| Pair 4 | PreInv - PosInv | -.19 | .24 | .04 | -.28 | -.10 | -4.49 | 30 | .00 |

The indication of those positive trends is not only showed quantitatively based on the questionnaire results but also is reflected by what students conveyed in interviews after SSI-lesson implementation. Instead of viewing as a difficult learning activity, finding the contextualisation of biology learning by SSI that was perceived by student after the learning process reflects a valuable meaning of SSI-based instruction for biology classroom. This view is revealed when students were asked about their experience in SSI-lesson, as represented by excerpt BFM-I as follows.

***The meaning of SSI in the classroom*** - Excerpt BFM-I

R : "Compared to teaching and learning as you usually experience with your teacher, what do you think about your learning experience like you did yesterday [with SSI]?"

Wh : "It was challenging for us to explore our ability, to be brave, revealing our opinion. But, on the other hand, it seems that it was hard for other students who prefer to be passive"

Lrs : "It was interesting! But, the problem is that our biology topic is too much. If we use that such kind of method [SSI], I worry that the topics won't be completed at the end of school time"

R : "Did you find any difficulties?"

Wh : "No, I didn't think there was a difficulty. I thought it was more challenging, because we learnt something related to biology that could be found from our daily life, and also could be discussed just like we did"

Lrs : "I did not think so. Instead of difficulties, I think we were definitely practicing our thinking skills (about a problem) that occurred based on our real-life environment. We usually do something monotonous, mostly memorizing theories"

It is considerably revealed based on excerpt BFM-I above that because SSI-lesson could provide a real-life related problem, SSI could potentially encourage students to find a meaningful context of biological knowledge and engage them in discussion activity as well as practice their thinking skills. Thus, it could be argued that being involved in such activities was perceived by students as an interesting and challenging experience rather than a difficulty.

However, besides being viewed as an advantage, students also considered a possible disadvantage that might occurred regarding SSI-lesson engagement. In fact, there was a challenge to engage students in the contextualisation as occurred at the beginning of the lesson based on an observed class situation. At the beginning, confusion about the topic was immediately expressed by a couple of students in the class when their teacher began the lesson by asking about the informal reasoning test that they just carried out. *"I was not sure how to answer it [the problem]!"*, replied one of student. *"It was confusing Sir, because we have not learnt it before"*, stated another.

The teacher, Mr. Budi, was trying to encourage his students by explaining that it would be something different for their learning: *"Unlike what we usually do, today we will be learning something different about human physiology, particularly about breastfeeding"*, said Mr Budi in his introduction. *"Maybe some of you know that breastfeeding actually is not a main topic in our book or curriculum, regardless it is only the complementary one. But, however, today we will learn it as a special topic"*, he continued his speak. In a short time before the teacher continued his teaching there were no responses or reactions from students on what teacher said.

Soon, the students paid attention to what teacher explained about the issue with media slides.

The above-described engagement session was illustrative of the tendency of a low intensity of students' involvement at the beginning of the class. But this situation immediately changed when students responded to Mr. Budi as he was explaining about a group activity. When the teacher told them that they will be doing a role play and asked them to arrange into their groups, students became hectic.

*"We want to be in our previous group, Sir!"*, suggested one student so that they could use the existing group which students already made before. *"Alright, we use the existing group"*, the teacher replied. *"What we are going to do, Sir?*, asked another student. The teacher then explained how they will be doing the role play which involved four main roles, including: 1) the local authority district of health, 2) religious affair authority, 3) group of community or consumers, and 4) the producers of formula milk. Again, students became excited as they wanted to play the intended role. They suggested to the teacher: *"Let us play as the customers, Sir"*, said one group. *"We want to be a group of producers"*, asserted another one. However, the teacher further took the control to manage the groups and decided the role that they would play.

As a dynamic situation emerged, it was generally viewed that most of students were involved in and tried to contribute to discussion by delivering his/her idea or opinion. However, a very limited number of students tended to be passive and preferred only to be quiet listeners, or acted as a clerk and wrote down the results of the group discussion in their worksheets. Regarding the idea or opinion delivered in the discussion, it was likely that students tried to apply multiple perspectives on their discussion. In the group roleplaying as customers, for instance, at a particular time during the discussion, they were focusing their talks on the perspectives of working and non-working mothers to deal with the issue, as represented by the following excerpt:

***A group discussion of the issue*** - Excerpt BFM-II

| | | |
|---|---|---|
| Student 1 | : | "I think it is not a problem for a non-working mother. The problem is for a working mother as she has to go to work and it seems impossible to give breastfeeding. So, supplying her baby with formula milk could be a solution" |
| Student 2 | : | "Actually it depends on the mother's intention. If she intends to give it [breastfeeding], she could do it. She can try to milk and deposit her breastmilk in the fridge and supply it to her baby whenever the baby needs it. That is a contemporary way that I know today" |
| Student 1 | : | "But it still needs someone else to supply the milk to the baby, because the mother is still in her work" |
| Student 2 | : | "Well, I believe that whilst the mother is working, her baby is staying at home with relatives or other family members, grandma, perhaps. So, it still possible to do that" |
| Student 3 | : | "Do you think that women celebrities, movie stars or singers, shall give their baby the breastmilk? They do not go to work regularly, not every day, but I am not so sure they do it" |
| Student 4 | : | "Again, it depends on their intention" |
| Student 5 | : | "The main problem is, what is our decision? Agree or not to the doctor's note?" |
| Student 3 | : | "That is my concern. I think it is every mother's right to decide what she would like to give to her baby, breastmilk or formula" |
| Student 2 | : | "Breastmilk is the best, right?!" |
| Student 1 | : | "We should know first the reason why a mother wants to give formula, instead of breastmilk, to her baby?" |

In excerpt BFM-II above, the group roleplaying as customer was discussing about atmosphere when they tried to decide their position toward the issue. Regarding their internal negotiation, even though they were in the same position (i.e. being customers), each group member was encouraged to be involved in group discussion by delivering opinion from different perspectives. A stand point that emerged in this discussion revolved around a dilemma faced by a working mother on the best way to give appropriate nutrition for her baby. This stand point then unfolded to

other aspects, such as personal intension and family role, and led the discussion being attractive. However, in this situation, an interesting fact occurred when a group member tried to remind his/her groupmates about their main task of group position toward the issue. Hence, a dialogue which was constructed by the group of customers above represents a good engagement in the group.

A similar spirit of engagement, furthermore, was also viewed in other groups, such as the group of religious affairs authority or the producers of formula milk. As all students in the group are Muslim, the group of religious affairs authority emphasised their talks on the Islamic values such as the history of Prophet Muhammad when he was breastfed by his adoptive mother. Moreover, students also referred to some knowledge sourced from The Holy Quran as well as Prophet Muhammad's thoughts regarding the importance of breastmilk intake. In the group roleplaying as the producers of formula milk, on the other hand, students focused on the advantages of the products particularly in regard to nutrient content that could make the products as an appropriate substitute of the breastmilk and be offered to the costumers. Therefore, the described group discussion atmosphere reflect the way students were involved in their group activities and may support the trends of the positive change on the scale of involvement of students' perception of SSI-lesson.

The perceptions of involvement in the SSI-group activity as described above may also indicate a positive attitude toward SSI-lesson that was perceived by students. As previously mentioned that students were attracted to SSI-group discussion, the following excerpts from the interviews further support how students considered some particular aspects that necessarily occurred in or might influence their SSI learning.

***Student attitude in SSI-group discussion*** - Excerpt BFM-III

| | | |
|---|---|---|
| R | : | "Which one do you prefer, learning biology like we did or just doing as previously?" |
| Lar | : | "Like we did, regardless of the fact that we have so many biological topics that need to be learnt. So, maybe, sometimes, we need to do it a different way" |

R : “In regard of your discussion, when you were sharing ideas toward making a decision (about the issue), did you find any difficulties?”

Lar : “Yes, I did. In one group, all students were unable to provide their ideas or opinions. Only one or two of us were actively involved. The others just remained silent. We thought it was not good to make a discussion if not all of students were involved”

R : “For those who previously disagreed (toward group decision), they changed their minds to follow the agreement. It is suggested that there was a consideration that made you reach a deal, and, what was that?”

Lar : “We considered the opinion whom not disagree was not such better than others”

***Student attitude in SSI-group discussion*** - Excerpt BFM-IV

R : “Compared to teaching and learning as the teacher usually does, what do you think about your learning experience like we did yesterday (with SSI)?”

C : “I think what we did yesterday was more effective. When we are doing in common, the teacher explains the topic and gives a chance to ask, usually only a limited number of us is actively asking. Whereas what we did yesterday, most of us were able to contribute, were curious and willing to share ideas each other”

R : “Did you face any difficulties (or challenges)?”

C : “The challenge was how we make a conclusion. In my view, it seemed that my friends were not only sharing their ideas, but also, they were intent to impose their ideas on the group. It should not be like that. We were supposed to show better ideas so that we could make us consider, understand, which idea are the best or most appropriate. But what was happening was just discussing the same facts”

R : “Which you will prefer, learning biology like we did before or just doing as in common?”

C : “I prefer in various ways. What we did yesterday was considerably effective. But, the biological topic was not so clear for me. Besides, it was something different for us, so we were challenged. Perhaps if we already have common experience with that method, we will get more understanding”

R : “One of your friends stated that it was hard to make a conclusion. Do you think it was due the uncertainty on the issue being discussed?”

C : “It can be said like that, because we did not find any solutions to the problem we discussed”

The above excerpts illustrate the way students considered their role as well as the things needed to present in the SSI-lesson. Aspects such as an awareness to seek more information or how to make a good opinion as well as decision, were taken into students views. Moreover, according to the excerpt BMF-IV-C (2), for example, student also perceived a great challenge of SSI-learning particularly in regard to the way each group member should commit to SSI-discussion appropriately in order to reach a best decision toward the issue. Thus, it is suggested that students are pretty aware of certain things that are necessary in order to have a meaningful SSI-learning experience.

According to Table 5.1, a positive trend of SSI-learning experience was also represented for the dimension of learning objectives. It could meant that SSI-learning could accommodate students to achieve a distinct learning outputs in their biology classroom. This perception was also revealed through interviews as reflected by the following excerpts:

***SSI-learning achievement*** - Excerpt BFM-V

| | | |
|---|---|---|
| R | : | "Do you think you obtained different things, besides biological knowledge?" |
| C | : | "A social view was the most aspect that emerged during the discussion, such as economics or religiosity. It was not too much biological knowledge, but was maybe disguised" |
| R | : | "But, could you view the biological knowledge associated with the issue? Can you give an example?" |
| C | : | "It was about, for example, the nutritional content of milk for a baby" |
| R | : | "Did you feel a particular challenge?" |
| C | : | "Our skill to communicate, giving our opinion. I rarely give my idea. But I was attracted to share ideas, regardless whether mine was not strongly appropriate" |
| R | : | "Did you think you would like to change your decision?" |
| C | : | "Yeah, why not?" |
| R | : | "When you make a decision, did you think each of you needs more information? Or, did you think that the entire information you got was appropriate?" |
| C | : | "We need to seek supportive information" |
| R | : | "Such as?" |
| C | : | "Proof on a baby's growth who consumes formula milk, particularly on her/his brain development" |

| | | |
|---|---|---|
| R | : | "And did you think you have enough information?" |
| C | : | "Nope, it was not so appropriate" |

***SSI-learning achievement*** - Excerpt BFM-VI

| | | |
|---|---|---|
| R | : | "Do you think you obtained different things, besides biology knowledge?" |
| S03-B | : | "The biological aspect was not dominant, because there were other aspects such as health, economics, or religious issues" |
| R | : | "Did you view the biological knowledge associated to the issue? If so, what was that?" |
| S03-B | : | "It was about biological effect of formula milk to babies, and also how emotional relationship between mother and her baby" |
| R | : | "Specifically, related to the biological topic; breast feeding, formula milk, and babies health?" |
| S03-B | : | "It was about the social aspect of the issue of formula milk" |
| R | : | "Did you feel a particular challenge?" |
| S03-B | : | "The challenge was about our role that we were playing. As we played as the producer, other group viewed that the formula milk is just for a substitution, and not as important as breastmilk" |
| R | : | "You meant it was about different perceptions about the issue?" |
| S03-B | : | "Yes, exactly" |
| R | : | "When you made a decision, did you think each of you needed more information? Or, did you think that the entire information you got was appropriate?" |
| S03-B | : | "We needed more information on the proof of nutritional content (of formula milk) as well as its hygiene" |
| R | : | "Did it encourage you to analyse scientific information, or argue or debate with your friends?" |
| S03-B | : | "Yes it provided an argument about selecting which method of reproduction that is best to be applied" |

According to the above excerpts, there are three dimensions of learning objective which were considerably perceived by student. The first is about the biological knowledge as the student stated, for example, the nutritional content of as well as a possible effect of formula consumption to baby. The second is about the social consideration to the issue. The third is the awareness on decision making related skills, such as seeking an appropriate information or dealing with different idea. Furthermore, the research finding also suggests that SSI-learning potentially led

student to reflect on his/her learning pathways and value about the appropriate strategy for his/her preferred biology instruction. An example of this finding is represented by the excerpt BFM-VII below:

***A preference of biology classroom climate*** - Excerpt BFM-VII

| | | |
|---|---|---|
| R | : | "Compared to teaching and learning as your teacher usually does, what do you think about your learning experience like we did yesterday [with SSI]?" |
| Nik | : | "I prefer to what we usually do in common, because I can understand the topic in certain manners indeed. Unlike what we did, it was lack of certainty, and because of many opinions. I could not grab the conclusion" |
| R | : | "Did you feel any difficulties?" |
| Nik | : | "Not at all. But actually I prefer, more pleasant to study in the way of our teacher does usually" |

Excerpt BFM-VII indicates that student's orientation on what he/she will gain in biology classroom (i.e the expected learning objectives) is one possible factor influencing his/her preference on biology instruction. Dealing with this orientation, previous biology classroom is viewed more preferable than SSI-based instruction. It is suggested that uncertainty about opinions delivered as well as the end-point of the SSI-discussion are perceived as unpleasant compared to previous (i.e usual) biology classroom environment.

## 5.3 Students' Experience and Perceptions of SSI-based Learning on Issue #2: Mobile phone and society

### (A) Students: Grade 11 of SMAN 11 Yogyakarta

It is interesting to note that, based on the Figure 5.2, the scale of contextualisation was perceived differently by students after the SSI-lesson with a slightly reduced mean value. On the other hand, although there were positive trends, each of the three other scales – learning objectives, attitude toward SSI-learning, and

involvement – did not represent a strong sophisticated meaning as the values did not reach the agreement view (i.e score of four). Moreover, the result of a paired t-test also reflects this meaning as not being statistically significant ($p<.05$) as represented in Table 5.2.

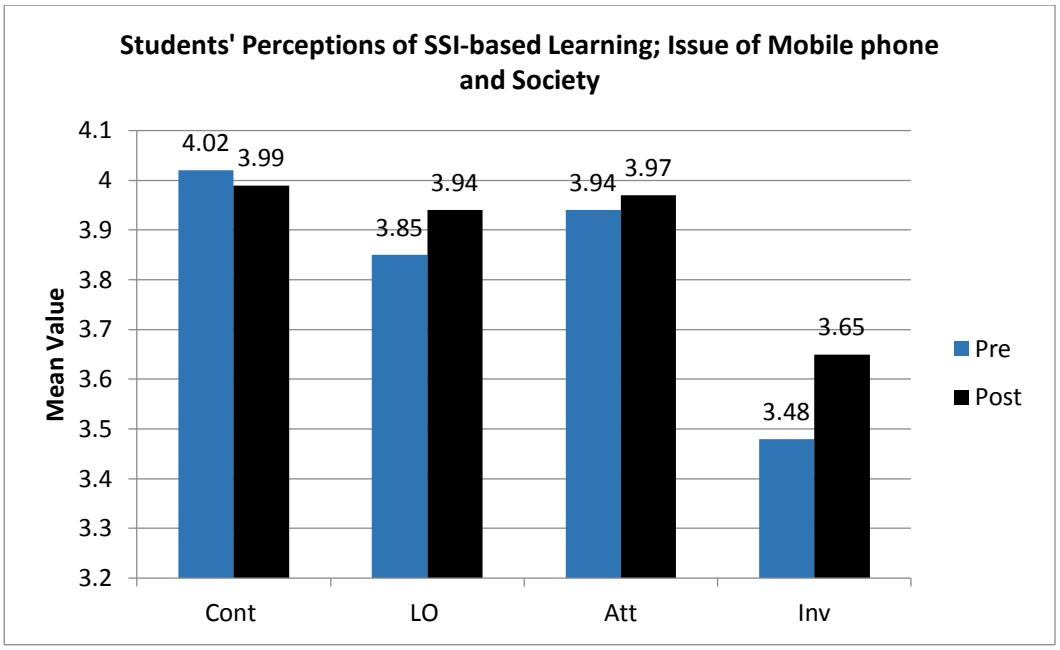



Figure 5.2 Students' perceptions of SSI-based learning on the issue of mobile phone and society from a grade-11 class of SMAN 11 Yogyakarta.

Table 5.2 Paired t-test of mean value for each scale of perception of SSI-based learning on issue of Mobile phone and society before and after the instruction of a grade-11 class of SMAN 11 Yogyakarta

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | PreC - PosC | .04 | .26 | .05 | -.06 | .15 | .84 | 26 | .41 |
| Pair 2 | PreLO - PosLO | -.09 | .30 | .06 | -.21 | .03 | -1.49 | 26 | .15 |
| Pair 3 | PreAt - PosAt | -.03 | .39 | .07 | -.18 | .12 | -.40 | 26 | .69 |
| Pair 4 | PreInv - PosInv | -.16 | .48 | .09 | -.36 | .02 | -1.79 | 26 | .09 |

However, although it is not statistically different, the degree of value of SSI-based instruction for student learning experience and perceptions could be viewed in qualitative perspective. In this regard, particularly, students' perceptions of their involvement in the SSI-learning looks to be more valuable than their previous learning experience based on what they experienced at the beginning of the lesson.

When the teacher (Mrs. Dwi) was illustrating the background of the issue, students tended to be passive and just sat silently. The teacher spent more than half a lesson teaching an introduction, taking a dominant role in the class with a long talk. It was viewed that students were listening to the teacher when she was delivering a story about the culture of communication in the society and how it might be changed because of the technological development particularly of the massive product and application of mobile phones. However, even though she gave students a chance to ask or tell something related to the story, students were quiet and no one addressed his/her response to teacher. This situation did not change even when the teacher began to emphasise her talk about the issue by showing teaching slides. There was no two-way interaction between the teacher and students because the students paid attention to teacher whilst she focused on her slides.

What can be deduced from the above depiction was a lack of attention paid by the students during the introductory session. While a few chances were given for students to ask a question or give an opinion it seemed that students did not intend to express any particular response. It is suggested that certain factors might lead students to being not really attracted. Hence, a review of students' reflections through interview after the lesson revealed potential factors that may have influenced the way the students perceived their involvement at the beginning of the lesson, as shown in the following excerpt:

***Students' experience on contextualised learning*** - Excerpt MpS-I

R : "What we learnt [yesterday] began with a social issue related to biology. Have you ever learnt biology like we did [based on SSI] before?"

| | | |
|---|---|---|
| A | : | "No, we have no experience like that. But, I rarely read such issues via the internet. About the issue [mobile phone and society], we never discussed it, especially its effect toward our health" |
| R | : | "Was it your first experience?" |
| A | : | "Yes, as most commonly our lesson is based on our book and sometimes our teacher asks questions" |
| R | : | "Have you tried to reconsider biology topics that you have learnt in your daily life?" |
| A | : | "Usually we see [observe] a phenomenon and further we discuss it in the class" |
| R | : | "Did you find any difficulties?" |
| A | : | "It made me surprised, because usually we just learn in an ordinary way, where the teacher mostly explaining the topic based on text book, but suddenly we learn about something different, it was strange" |
| R | : | "Do you think which one is easier, learning like we did or as teacher does as usual?" |
| A | : | "I prefer to what we did (yesterday), as we were encouraged to think creatively, be able to deliver our opinion, and also have more confidence. But, otherwise, perhaps some of us depend on other friends' opinions" |

***Student experience on contextualised learning*** - Excerpt MpS-II

| | | |
|---|---|---|
| R | ÷ | "What we learnt yesterday began with a social issue related to biology. Have you ever learnt biology like that [based on SSI] before?" |
| Mar | : | "Never, and it was my first experience" |
| R | : | "Compared to teaching and learning as your teacher usually does, what do you think about your learning experience like we did (with SSI)?" |
| Mar | : | "What we do usually is just listen to what our teacher explains. It is different with what we did yesterday, as we cooperated in a group discussion. Besides, we will understand more about the topic" |
| R | : | "Found any difficulties?" |
| Mar | : | "Instead of difficulty, it was really interesting for me, because we were not only learning about biology, but also about social aspects. The issue encouraged me to explore broader matters. So, it was not really difficult for me" |

R : "Any specific problem?"
Mar : "For some new matters, like the term of 'SAR' [Specific Absorption Rate], that made us to look for more details"
R : "Have you tried to reconsider the biology topic that you have learnt in your daily life?"
Mar : "Ehm…, I am not so sure about that"

According to these excerpts, it can be pointed out that the way the students were usually taught (i.e by book-based discourse or teacher's lecturing or explanation) and the lack of experience on learning with social-related problems might lead to a lower degree of involvement at the lesson. Contrary to this, the SSI-learning implemented in this class did accommodate students to be more engaged. The following excerpts support this point of view:

***The meaning of SSI for student involvement*** - Excerpt MpS-III

R : "About the issue, do you think it influenced your understanding about the biological concept being learnt?"
B : "I think yes, and I saw it was more than biology since we talked about social impact too. We were encouraged to seek relevant information that we need to understand and, further, we need to convey our ideas to others."
R : "Previously you stated about your experience on discussion activity, how the group discussion was usually carried out in your biology lesson?"
B : "So far the teacher shares the tasks and then collected them together"
R : "What about the discussion that we did? Do you think you were motivated to share your idea?"
B : "Yes, the different opinion in our group encouraged me to share our ideas, and what an interesting is, it could lead a debate"
R : "How was your friend involved?"
B : "Different opinions encouraged us to express our ideas, and the interest generated a debate"
R : "Was it challenging you?"
B : "Yes, how we stand up on our opinion or idea, even though it might be wrong"

| | | |
|---|---|---|
| R | : | "Better on what? – Any factors that support your idea and determine if it [idea] is true or false?" |
| B | : | "By information about the opinion which I looked for before, that underpinned the truth of my opinion. Otherwise, if my opinion is definitely different with most others, so maybe it [my opinion] was wrong" |
| R | : | "Did you have any experience on learning with seeking and examining information" |
| B | : | "I have, but very limited" |
| R | : | "Compared to teaching and learning as the teacher usually does, what do you think about your learning experience like we did yesterday (with SSI)?" |
| B | : | "I prefer what we did yesterday. There is another meaning, related to our daily life" |

***The meaning of SSI for student involvement*** - Excerpt MpS-IV

| | | |
|---|---|---|
| R | : | "About the issue, do you think it influenced your understanding about the biological concept being learnt?" |
| Mar | : | "The social aspect or values, the application of our biological knowledge in daily life" |
| R | : | "Did it challenge you?" |
| Mar | : | "Whilst we thought that our friend's idea was not right, I was challenged to make it better. But, on the other hand, I must have a strong basis of my opinion. The challenge was how to convince others" |
| R | : | "Did you have experience on that [such activity]?" |
| Mar | : | "Not for our biology lesson" |
| R | : | "So, you became to understand about information required and how to find it?" |
| Mar | : | "Yes, we learnt it" |
| R | : | "What about the teacher's role?" |
| Mar | : | "I do not really like the way our teacher teaches us because she is mostly using power point presentation. There is no opportunity for us to write what is being explained. Besides, teacher sometimes tells story while explain, so we could not focus" |

The above excerpts considerably highlight some essential findings regarding student engagement to the SSI-learning. These are:

1) A valued meaning of SSI-learning was reflected on how student dealt with SSI-group activity, such as being more engaged in discussion, challenged to share better ideas or argument, and interest to having a debate toward the issue. These represent attitudes expressed by the student during their SSI-instruction.
2) There is also a perception of SSI-learning objectives that could be achieved by students. It includes an awareness of seeking information to support idea or argument toward the issue. Moreover, students also perceived other learning objectives besides biological knowledge, including social values of the topic and the application of biology concepts.
3) An emergence of self-regulated learning perspective stated by students in regard to their learning experience was also revealed. Considerably stated in excerpt MpS-III-B (8) or MpS-IV-Mar (5), it mainly relates to the way their biology teacher taught them as well as about limited experience on learning with seeking and examining scientific information.

Those first-two points are likely in alignment with the trends of change on the dimension of SSI-learning objectives and attitude toward SSI-learning. And like in section 5.2, the third point could be viewed as a special finding as well.

**(B) Students: Grade 11 of SMAN 1 Kasihan, Bantul.**

As represented by Figure 5.3, questionnaire-based results on grade-11 students' perceptions of the SSI-based instruction for the issue of mobile phone and society in SMAN 1 Kasihan, Bantul, show a change for each dimension of perceptions. These results are supported by paired t-test values of perceptions which show statistically significant differences ($p<.05$) between pre and post instruction as shown in Table 5.3.

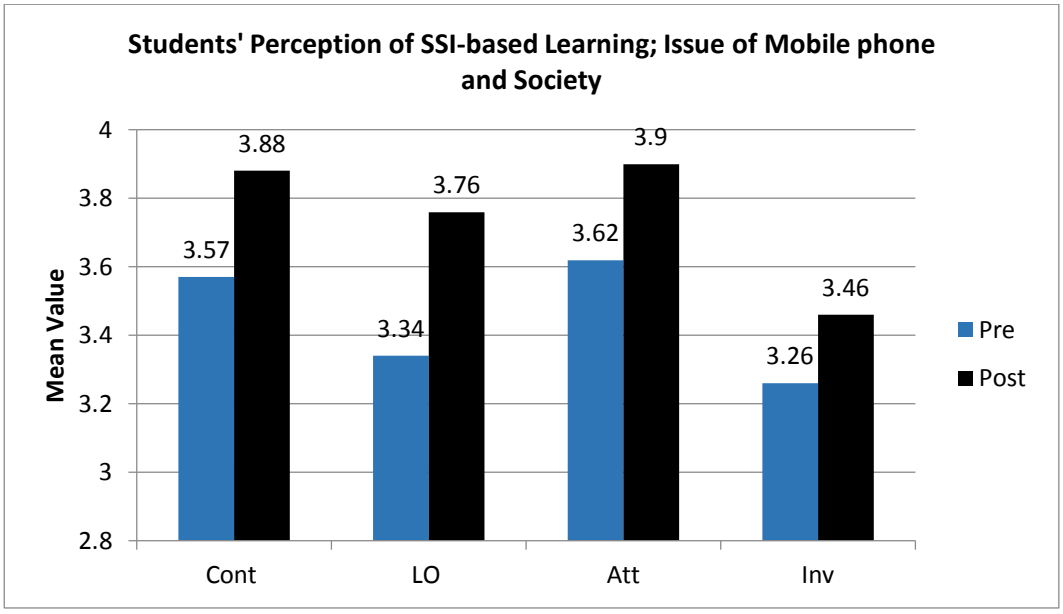



Figure 5.3 Students' perceptions of SSI-based learning on the issue of mobile phone and society from a grade-11 class of SMAN 1 Kasihan, Bantul.

Table 5.3 Paired t-test of mean value for each scale of perception of SSI-based learning on issue of Mobile phone and society before and after the instruction of a grade-11 class of SMAN 1 Kasihan, Bantul.

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Dev | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | PreC - PosC | -.31 | .17 | .03 | -.37 | -.24 | -9.91 | 30 | .00 |
| Pair 2 | PreLO - PosLO | -.42 | .35 | .06 | -.55 | -.29 | -6.59 | 30 | .00 |
| Pair 3 | PreAt - PosAt | -.28 | .26 | .05 | -.37 | -.18 | -5.90 | 30 | .00 |
| Pair 4 | PreInv - PosInv | -.19 | .24 | .04 | -.28 | -.10 | -4.49 | 30 | .00 |

The positive trends of students' perception after the SSI-lesson reflect a valuable meaning of SSI-based instruction. The first valuable meaning is a consideration of a distinct experience perceived by students compared to their previous learning, and the following interview excerpt supports this finding:

***Student experience on SSI & contextualised learning*** - Excerpt MpS-V

| | | |
|---|---|---|
| R | : | "Have you ever learnt on the way we did yesterday?" |
| A | : | "No, we have not" |
| R | : | "It means it was your first experience?" |
| A | : | "Yes it was" |
| R | : | "What do you think if we compare what we did yesterday with your common biology class? Do you think it [SSI] is suitable with the biology topic?" |
| A | : | "I do not think it is really suitable with our basic need of curriculum. However, such a topic is also necessary for us so we can understand more about the impact based on the biological knowledge. That is what we can see in our daily life" |

Excerpt MpS-V above reveals that the student acknowledged the SSI-based lesson implemented in his/her biology class was his/her first experience to learn with it. Student also viewed an advantage of SSI-lesson to find contextual meaning of the biology topic. These findings, thus, may confirm a positive trend on the dimensions of contextualisation of SSI-lesson. Furthermore, review on the perception of the dimension suggests that students were impressed with the learning activities in which they could be more active. As a supporting evidence, the following excerpts illustrate the impression:

***Group discussion atmosphere*** - Excerpt MpS-VI

| | | |
|---|---|---|
| R | : | "Found any difficulties?" |
| A | : | "I do not think it was difficult" |
| C | : | "When doing the discussion, it seemed that the pros-groups were right. Otherwise, in my view, it [the truth] depends on the point of view" |
| R | : | "Have you reconsidered what you learnt in biology to daily life?" |
| A | : | "Mhh, [what I can say here] maybe about traditional massage" |
| C | : | "About internal organ and illness indication" |
| R | : | "Do you think which one is easier or more convenient for you, a class like we did or like as usual with your teacher?" |
| A | : | "I prefer like we did, as we are encouraged to be more active. If doing as usual, to be honest, I am bored. Sometimes it makes me sleepy" |
| C | : | "What we did is something new for us, so it is really interesting" |

***Group discussion atmosphere*** - Excerpt MpS-VII

| | | |
|---|---|---|
| R | : | "So, did you see any difficulties learning with it [SSI]?" |
| A | : | "When we had a discussion with a worksheet, I found some terms that we did not know before, such as SAR" |
| R | : | "So, why was it difficult?" |
| A | : | "Because we did not hear it before" |
| R | : | "Had experienced a similar issue before?" |
| A | : | "About hand-soap, it is suggested that the liquid is more secure than other soaps" |
| R | : | "So, do you think which one is easier for you, learning like we did or as usual?" |
| A | : | "Like we did, because we can see who is really active, involved and engaged to share his/her mind in group discussion" |
| R | : | "Why you said so? What did you feel?" |
| A | : | "Because we can interact more intensively with each other. But, when doing [group] activity as usual, those who think they do not understand, and tend to be passive. But, by the pattern like we did, we will consider others' ideas and opinions" |

Based on those excerpts, the way student perceived their experience in the SSI-learning activity reveals an essential finding for this research. As SSI promotes a real context of the problem in biology topic and with support of group activity where students are able to share their idea or reasoning, SSI-learning potentially attracts students to be more involved in their learning activity. Perceived in a distinct meaning where previous (or usual) learning situation could make students feel bored or sleepy, SSI-group activity atmosphere, on the other hand, accommodate student to consider their arguments and negotiate opinion toward the issue. Moreover, this dynamic SSI-learning situation seems strongly associated with student attitude toward his/her role in SSI-group activity, as represented by the following excerpt:

***Group discussion atmosphere*** - Excerpt MpS-VIII

| | | |
|---|---|---|
| R | : | "Any challenges, perhaps, regarding a need to generate a decision in your group?" |
| A | : | "When we have a different opinion. It is a challenge to confirm all of our ideas" |
| R | : | "What did you do then?" |
| A | : | "We reviewed the information that we have" |

| | | |
|---|---|---|
| R | : | "How do you know the information that you have is good enough, fit with your needs?" |
| A | : | "Mhh…, we research the reference" |
| R | : | "Do you have experience on learning to seek and examine the information?" |
| A | : | "What we usually do is seek the information. But we have no experience how to examine the information" |
| R | : | "What about your group? Was there any interaction between you in the group?" |
| A | : | "There was an individual who just depended on others. When we were discussing and sharing about our decision, 'the one' only listened, and only followed the decision we made" |
| R | : | "What did you think about this situation? Do you see it was fair?" |
| A | : | "Well, I did not really care about him. But actually I hoped he was encouraged to say something" |
| R | : | "Personally, what exactly did you want in your group discussion?" |
| A | : | "Everyone is active" |

***Group discussion atmosphere*** - Excerpt MpS-IX

| | | |
|---|---|---|
| R | : | "Have you ever learnt the way we did yesterday?" |
| B | : | "No, we have not" |
| R | : | "How do you think?" |
| B | : | "It was interesting! It was easier for me to understand the topic by sharing our ideas or opinions with friends. We tried to not perceive that not only our idea was true, but that we have to consider others'.." |
| R | : | "Did you see any difficulties?" |
| B | : | "Trying to find the correct answer was the difficult thing" |
| R | : | "Do you think which one is easier or more convenience for you, learning like we did or like as usual?" |
| B | : | "Easier like we did, because it was easy to find our friend's answer or idea" |
| R | : | "Regarding the group discussion that you carried out, was there any difficulties or challenges?" |
| B | : | "I was worried for not really ready if someone refute my opinion. We have no experience and do not know how to argue with others. Sometimes, there is an opinion delivered in a bad manner, which is inappropriate. It is also an inconvenience" |

It is accentuated that dealing with a different opinion within group is challenging during SSI-discussion. This challenge may be advantageous for students as they need to aware about each group member idea. However, group discussion may also

make an inconvenience situation while group mate(s) would not like to be active participating in the discussion. This situation was also perceived by student as represented in excerpt MpS-VIII-A (5, 6), for example. Students' perception of inconvenience related to the way of group member deliver his/her opinion which is viewed inappropriately was also reflected in excerpt MpS-IX-B (10). These views are likely reflect students' attitude toward SSI-group activity.

The above mentioned excerpts, particularly of excerpt MpS-IX-B (2), show a special feature of perceptions where student implicitly pointed out his/her view on a learning achievement by stated his/her understanding upon the biological topic by SSI-discussion. Thus, it is suggested that SSI-learning potentially accommodate student to obtain certain learning achievements either knowledge or skills. The following excerpts also support this statement:

***SSI-learning achievement*** - Excerpt MpS-X

| | | |
|---|---|---|
| R | : | "So, by learning like we did, do you think it was easier or more difficult to understand the [biological] topic being discussed?" |
| A | : | "I think it was easier with learning like we did" |
| R | : | "Why? Do you think you learnt or obtained something else, other than biology?" |
| A | : | "Getting insight about the wider impact [of the issue] and to think more about the problem" |

***SSI-learning achievement*** - Excerpt MpS-XI

| | | |
|---|---|---|
| R | : | "Were you satisfied with the biological knowledge you learnt in the way we did?" |
| B | : | "Generally, yes. But, except for particular term, such as SAR, EMF, those were strange for me" |
| R | : | "Were you learning something else?" |
| B | : | "I considered the impact of technological development" |
| R | : | "What about social values of the issue?" |
| B | : | "Yeah, through a discussion activity in the group, when we shared our opinion" |

It is generally shown that, besides biological knowledge, students perceived a consideration on the social aspect of the topic within SSI-learning. Moreover, a

deeper thinking or an insightful view beyond the issue was highlighted by students for the meaning of SSI-learning outcomes. This aspect of learning achievement is likely related to the group activities in which students were involved and perceived before. Moreover, dealing with previous excerpts related to group discussion atmosphere, it should be noted here about special statements which represent the way students reviewed their experience on learning through SSI.

From excerpts MpS-VIII-A (4), and MpS-IX-B (2), for examples, students showed various reflection regarding what they had done in SSI-learning activity. An awareness of a lack of experience on examining information activity in previous learning, a consideration on the quality of opinion as well as the way to negotiate a distinct perspective delivered during the discussion, are aspects of reflection stated by students. These are likely showing a metacognitive perspective in students' perception of SSI-based learning.

## 5.4 Students' Experience and Perceptions of a SSI-based Learning on Issue #3: Hotel development and water resource; Grade 10 – SMAN 11 Yogyakarta

According to the questionnaire-based perceptions represented in Figure 5.4, students' perceptions of SSI-based learning on the issue of hotel development and water resource shows a positive change for each dimension of perception. However, based on statistical analysis with paired t-test, a significant difference of students' perception between before and after instruction only revealed for the scale of SSI learning objectives (LO) ($p<.05$) but not for other three dimensions.

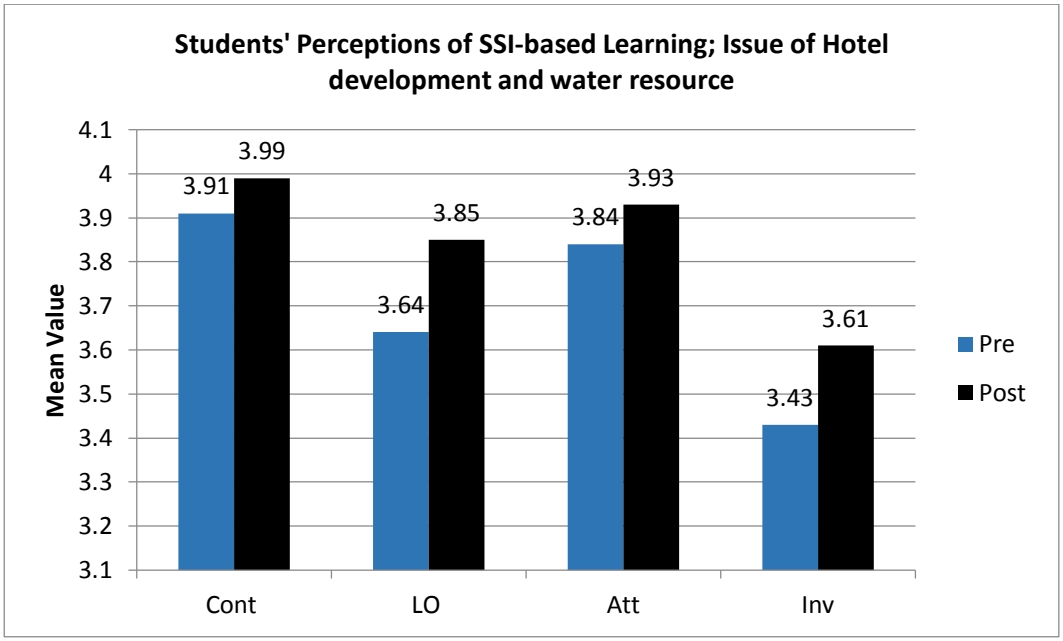



Figure 5.4 Students' perceptions of SSI-based learning on the issue of hotel development and water resource from a grade-10 class of SMAN 11, Yogyakarta.

Table 5.4 Paired t-test of mean value for each scale of perception of SSI-based learning on issue of Hotel development and water resources before and after the instruction

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Dev | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | PreC - PosC | -.08 | .54 | .09 | -.28 | .11 | -.89 | 31 | .38 |
| Pair 2 | PreLO - PosLO | -.20 | .46 | .08 | -.37 | -.04 | -2.55 | 31 | .02 |
| Pair 3 | PreAt - PosAt | -.09 | .55 | .09 | -.28 | .11 | -.90 | 31 | .37 |
| Pair 4 | PreInv - PosInv | -.18 | .57 | .10 | -.38 | .03 | -1.74 | 31 | .09 |

Reviewing the interview result may (or may not) reveal supportive evidence regarding the trends of perceptions change. Highlighted by excerpt HDW-I and II, a valuable meaning of SSI-based instruction was viewed by students regarding the role of SSI for providing a different experience for student.

***Valuable meaning of SSI*** - Excerpt HDW-I

| | | |
|---|---|---|
| R | : | "Compared to teaching and learning as teacher usually does, what do you think about your learning experience like we did yesterday (with SSI)?" |
| Dav | : | "It was interesting, different. Since, so far, our teacher usually applies power point slide presentations. It is monotonous" |
| R | : | "What we learnt yesterday began with a social issue related to biology, especially the environment. Have you ever learn biology like yesterday before?" |
| Dav | : | "Not yet. Usually our lessons are based on the slides (provided by teacher) and make the notes or doing exercise sheets" |
| R | : | "Did you immediately understand when the issue was provided prior to our lesson?" |
| Dav | : | "No, I did not. But after we worked with the worksheet and did an investigation, it was getting easier" |
| R | : | "Were you aware about such kind of issues like we discussed yesterday? |
| Dev | : | "No. We never thought like it before" |
| R | : | "Have you tried to reconsider a biology topic that you have learnt in your class?" |
| Dav | : | "About a raising of earth temperature, related to our daily life (habit) using vehicles, or inappropriate public transport that produces bad gas" |

***Valuable meaning of SSI*** - Excerpt HDW-II

| | | |
|---|---|---|
| R | : | "What do you think about your learning experience like we did yesterday (with SSI)?" |
| Din | : | "It was easier, as we have had a discussion prior about something emerged in our society so that we could figure out what we learnt, then we made a conclusion in a form of a decision. Usually, we do not have such discussion, it is only delivered by the teacher" |
| R | : | "How does your biology teacher usually teach?" |
| Din | : | "Using power point presentation, ask us to make a note what teacher explains, and doing exercise sheets" |
| R | : | "Comparing between learning with SSI and as you usually experience, which one is more challenging? Which one is your preference?" |

| | | |
|---|---|---|
| Din | : | "I prefer to SSI, as we could deliver our ideas, opinions through discussion. It makes me understand more according to opinions that has been shared" |
| R | : | "Compared to your learning experience, which one is your preference?" |
| Din | : | "I prefer discussion that was initiated with a problem. I think it is interesting if we have a conclusion based on shared-opinion from class mates, especially if I could be involved in that discussion" |

According to excerpt HDW-I-Dav (1), for example, it is revealed that the student perceived his/her previous learning as monotonous while SSI-lesson with group discussion gave a different experience. Perhaps it is likely a common reaction from anyone when facing a distinct environment and feeling interesting upon the situation. However, regarding SSI-lesson, it might be different and valuable as the student also perceived that his/her interest is was with the meaning of SSI-based instruction where he/she was committed. As represented by excerpt HDW-I-Dav (3) or HDW-II-Din (1), for example, SSI was perceived as easier to learn as it is related to real life context. Moreover, it could also be noted from the excerpt that SSI-discussion influenced the way students perceived their involvement in SSI-discussion as represented by excerpt III and IV below:

***The meaning of SSI for student involvement*** - Excerpt HDW-III

| | | |
|---|---|---|
| R | : | "In regard to the role play you did yesterday, did you experience that before?" |
| Dhi | : | "Our teacher has had asked us doing such group discussion after doing an observation" |
| R | : | "What was the challenging part of the role play?" |
| Dhi | : | "I do not think it was challenging" |
| R | : | "Was there any difficulties?" |
| Dhi | : | "I do not think so" |
| R | : | "Do you prefer your teacher lecturing or delivering the learning material?" |
| Dhi | : | "Mostly" |

Whilst excerpt III is likely to represent a lesser involvement in SSI-discussion perceived by student, the following excerpts HDW IV, on the other hand, reflects a different view showed by other students regarding SSI-group activity:

***Student attitude in SSI-activity*** - Excerpt HDW-IV

| | | |
|---|---|---|
| R | : | "We were doing a role play yesterday. In that activity, you were trying to defend your opinion against others' by looking for such appropriate information and argumentation. Was it challenging you?" |
| Dav | : | "Yeah, it challenged me to think about the issue or the problem deeper. And forced us to preparing our self toward the topic. It made me understand more" |
| R | : | "Was it difficult?" |
| Dav | : | "A lot of us would not be attracted to engage in such kind discussion" |
| R | : | "When you tried to make a decision (pros or cons), what did you need to consider?" |
| Dav | : | "Biological knowledge is the main consideration. If we already understand the biological knowledge which we need, probably we can be selective toward the proper information" |
| R | : | "Is there any factor that may determine your consideration so you may change your view?" |
| Dav | : | "My biological knowledge, so we are aware toward the truth definitely" |

An interesting finding of this research is the polarity of perspectives in the way student perceived whether SSI-learning is challenging. Based on excerpt HDW-IV, student considered SSI challenging since its activity encouraged him/her to prepare him-/herself to be involved in the discussion. Thus, this challenge made him/her get more understanding to the topic. Unlike this perception, another student ("Dhi", excerpt HDW-III, for example) has a contrary view as the student perceived the SSI-instruction neither challenging nor difficult. A following review to the excerpt reveals that student's learning style might be an important factor to this finding as the student stated that he/she mostly preferred to be taught by lecturing.

Furthermore, dealing with SSI-group activity, there is an extent to which learning objectives achievement is also perceived by students. This is evidently represented by the following interview excerpt:

***SSI-learning achievement*** - Excerpt HDW-V

| | | |
|---|---|---|
| R | : | "Do you think it [your knowledge] has been changing after the lesson?" |
| Al | : | "Yes" |
| R | : | "So, if we compare to the way you learn biology in common, what do you think about learning with SSI?" |
| Al | : | "Since it provided a real example (description) about water cycle, it was illustrated in my mind" |
| R | : | "What do you think about your biological knowledge? Did the SSI influenced it?" |
| Al | : | "Yeah, it represents a real example, with the simulation indeed. Made it clear" |
| R | : | "Do you think you obtained different things, besides biological knowledge?" |
| Al | : | "Discussion, cooperation, unselfish, respect to others' opinion" |
| R | : | "Anything else?" |
| Al | : | "Being concern, since we learnt about legal aspect, our attitude, social values, respect, biology (environment), economics, politics, sociology, in which all those things are related to each other" |
| R | : | "Did you seek additional information about the text provided?" |
| Al | : | "No, I did not. Just read the news, then discussed it with my friend. I will let my classmates seek the information via internet. And when we debate the issue, we then would defend our opinion" |
| R | : | "Did you face any difficulties regarding making a decision" |
| Al | : | "None at all" |

Exemplifying the former quotations, excerpt V reveals that besides an insightful knowledge related to the issue and information process toward decision making, social aspects were also considerably perceived by students when participating in the SSI-lesson for the issue of the hotel development and water resources.

## 5.5 Students' Experience and Perceptions of a SSI-based Learning on Issue #4: Motorcycle driven by students; Grade 10 – SMAN 1 Kasihan, Bantul

The most attractive feature shown by Figure 5.5 is the extent to which the dimension of attitudes toward the SSI-lesson was perceived to a lower degree after SSI-lesson and was different to the dimension of involvement which showed a positive trend. It is also interesting to know that students' perceptions were relatively similar for both dimensions of contextualization of SSI and SSI-based learning objectives either before or after SSI-based learning. Referring to the paired t-test analysis, the results in Table 5.5, show that the difference of mean values for each dimension of perceptions before and after instruction did not show a statistically significant value ($p<.05$).

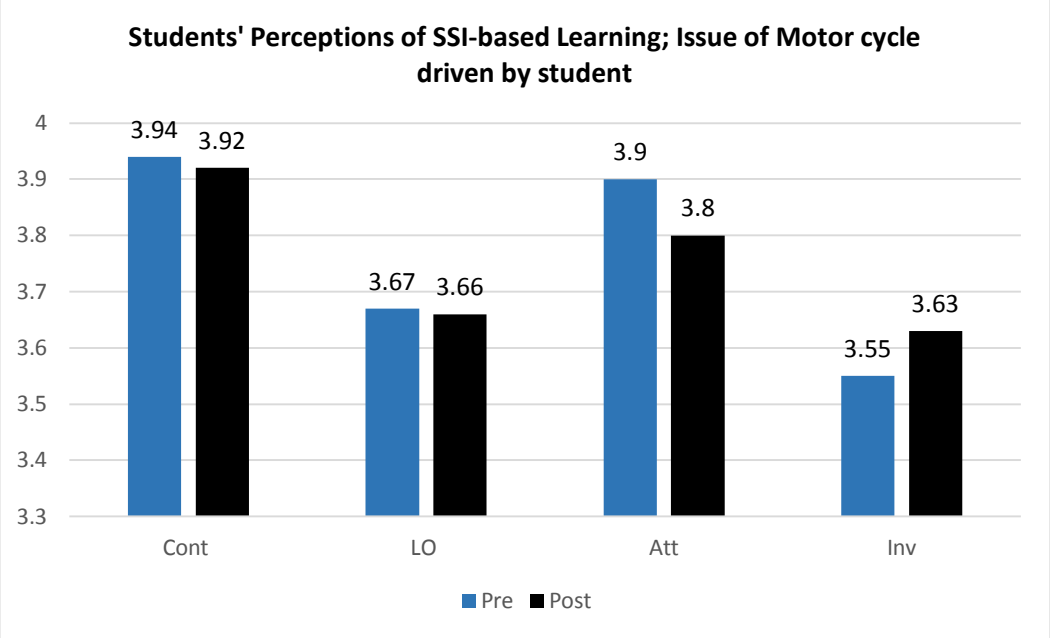



Figure 5.5 Students' perceptions of SSI-based learning on the issue of motor cycle driven by student from a grade-10 class of SMAN 1 Kasihan, Bantul.

Table 5.5 Paired t-test of mean value for each scale of perception of SSI-based learning on issue of Motor cycle driven by student before and after the instruction.

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | PreC - PosC | .02 | .31 | .06 | -.09 | .14 | .42 | 29 | .68 |
| Pair 2 | PreLO - PosLO | .00 | .41 | .07 | -.15 | .16 | .07 | 29 | .94 |
| Pair 3 | PreAt - PosAt | .09 | .50 | .09 | -.10 | .27 | .94 | 29 | .36 |
| Pair 4 | PreInv - PosInv | -.08 | .58 | .10 | -.29 | .14 | -.74 | 29 | .47 |

Regarding the trend of the questionnaire-based results above, the interview findings may reveal the background of students' perceptions. Besides generally recognized as their first experience, students perceived the SSI-based learning implemented in their biology class in a distinct way. On the one hand, some students viewed that the usual instruction managed by their teacher is better than the SSI. On the other hand, in contrast there are also few students who viewed that it was a valuable experience to learn with SSI. These latter perceptions of their experience are represented in the following excerpt:

***Valuable meaning of the SSI-lesson*** - Excerpt McDS-I

R : "Have you ever learnt biology like yesterday (based on SSI) before?"

Ok : "I do not think we have. Our teacher usually lectures the topic, and sometimes with group discussion, but not based on an issue"

R : "Compared to teaching and learning as teacher usually does, what do you think about your learning experience like we did yesterday (with SSI)?"

Ok : "I prefer to what our teacher usually does. It is easier for me to understand by his explanations"

R : "How does your teacher usually teach you?"

| | | |
|---|---|---|
| Ok | : | "What I like from the way of our teacher teaching us is that he loves to tell a story. Based on the story, he engages us to understand such a topic. However, mostly he asks us to read our book and make questions on something that we could understand about the topic. Then, we will have group discussion to deal with the problems. If we cannot answer the questions, he will explain us" |
| R | : | "How was the teacher's role? What type of teacher do you think you like most?" |
| Ok | : | "He usually tells us a story and we often to listen to what he is telling about. I mostly prefer to be lectured and making notes, but I do not really like to do an independent task" |
| R | : | "Have you tried to reconsider about biology topic that you have learnt in your daily life?" |
| Ok | : | "About acid rain, why it is happens" |

According to students' quotes, a regular teaching and learning pattern of their teacher applied his teaching style that makes sense is an easiness to understand the biological topic which is more preferred by some students. However, for some others, although the teacher's style looked to be interesting, the SSI-based instruction provided a different learning environment that accommodated students finding contextual meaning of the topic as well as obtaining distinct learning outcomes. These preferences are more likely influenced by a learning style that was customized throughout students' learning experiences, as excerpt: *"… I mostly prefer to be lectured and making notes, but do not really like to do an independent task."* (Quote McDS-I-(4)). Quote McDS-I-(2), another instance, obviously asserted the tendency of student's preference. Regardless of the interview findings which may be insufficient to represent all students' perceptions, according to students' quotations it is suggested that the extent to which students' preference for their learning style, basic motivation and orientation, and also biology classroom culture which was ordinarily managed by their teacher, possibly influenced the way students perceived their attitudes toward SSI-learning activity.

***Student attitude in SSI-activity*** - Excerpt McDS-II

| | | |
|---|---|---|
| R | : | "In your view, how does an interesting biology learning look like?" |
| Y5 | : | "A fun teacher, clearly explaining, telling stories, and motivating students" |
| R | : | "How does your teacher usually teach you?" |
| Y5 | : | "He teaches with fun, not focus on the books, and begins with something from our daily life activity. With question and answer method, discussion or observation. We are asked to read, make questions about what we have read, and in the groups, we all are asked to answer those questions" |
| R | : | "Compared to teaching and learning as the teacher usually does, what do you think about your learning experience like we did yesterday (with SSI)?" |
| Y5 | : | "As there were pros and cons groups, it was really challenging. Besides the topic was strongly related to the motor cycle and our daily life, it was interesting" |
| R | : | "Have you learnt with SSI before?" |
| Y5 | : | "No" |
| R | : | "Have you tried to reconsider about biology topic that you have learnt in your daily life?" |
| Y5 | : | "I have, but not sure… [Otherwise] I never think about the emission produced by motorcycle driven by students may reach a sufficient level and contribute to the greenhouse effect. I thought this city [Jogjakarta] is not like other big cities. Here the condition of the air is still good quality. So, I never think about the impact [of the motorcycle emission]" |
| R | : | "Which one do you think is more appropriate or convenient for you?" |
| Y5 | : | "By the issue [SSI]. It is forgettable if we learn as usual, reading the materials, group discussion for answering questions from teacher. Otherwise, being provided with an issue priory followed by discussion and teacher's explanation, we will understand more" |

According to those excerpts, whilst the way of teaching usually enacted by their biology teacher looked pleasant, on the other hand, students also perceived an attractive environment of SSI-based lesson where they were challenged to be involved in group discussion as well as argumentation. It is viewed that this

perception of the SSI-based lesson is likely in alignment with their learning preference. Moreover, an obvious reflection of the learning achievement was also perceived when student stated about their understanding of the lesson. Dealing with the learning objectives that students might attain, the following quotes revealed this to be evident:

***SSI-learning achievement*** - Excerpt McDS-III

| | | |
|---|---|---|
| R | : | "Did you think learning with SSI yesterday is easier to understand?" |
| Ok | : | "I was unable to understand the first task. But after the teacher went through the lesson, I got it [understanding]" |
| R | : | "Did you find any difficulties in the group discussion?" |
| Ok | : | "To look for and define reason [data] that can support the decision" |
| R | : | "What do think about the worksheet, was it helpful for you to find appropriate information?" |
| Ok | : | "Yes, particularly for activity #2, because we can know how much emission has been produced, and it made me think about what will happen if more people [students] drive their motorcycle" |
| R | : | "When you tried to make a decision (pros or cons), what did you need to consider about?" |
| Ok | : | "Each individual interest, then we compared and reconsidered with negotiation" |
| R | : | "What did you obtain, besides biological knowledge, from learning with SSI?" |
| Ok | : | "I was thinking about the law, regulation. Wondering if the government can provide public facility [i.e public transport] or better access [i.e roads] which is appropriate and convenient. But, otherwise, everything depends on people awareness especially to reduce their habit of driving motorcycles" |
| R | : | "Do you think it (SSI) could change your habit?" |
| Ok | : | "We obviously understand. But unsure to change our life habit" |

***SSI-learning achievement*** - Excerpt McDS-IV

| | | |
|---|---|---|
| R | : | "Regarding group discussion for making a decision toward the issue, is there any challenge?" |
| Y5 | : | "Different ideas, or points of view, expressed by group mates, related to factors that underpinned their opinion" |
| R | : | "So, how did you make a decision in your group?" |

| | | |
|---|---|---|
| Y5 | : | "Based on information or evidence that was found. But, again, it is hard to convince other friends [who have different views]" |
| R | : | "What factors supported your group negotiation?" |
| Y5 | : | "We mostly consider personal needs or interest, such as being tired when going to school by bike" |
| R | : | "Did your worksheet support you to find relevant information?" |
| Y5 | : | "Generally yes, and when we also considered the amount of emission produced, we know about the impact" |

Substantiating the before mentioned responses about SSI-learning achievements shows that besides understanding the topic, social and ethical considerations are the two main SSI-learning objectives perceived by students. Government policy to accommodate an appropriate facility related to the issue (i.e. public transport), self-awareness, and showing respect particularly when dealing with other's idea or opinions related to the issue are evidence which support their perceptions of the SSI lessons.

## 5.6 Discussion

This chapter is basically written to answer research question #2: *"What are Indonesian students' perceptions of SSI-based learning in biology?"* Hence, according to the research framework, this research applies a basic proposition to examine and analysis students' perceptions of SSI-learning. The proposition is comprised of four dimension, including: contextualisation of SSIs, attitude toward SSI-learning, student involvement, and SSI-learning objectives.

These dimensions also function as scales that construct an instrument of SSI-based instruction (see Chapter 4). Using the developed questionnaire, and also with observations as well as interview, data of students' perceptions of SSI-learning were collected. Based on analysis framework, those four dimensions are used to analyse as well as interpret the data. Thus, the following sections are presented to discuss students' perceptions of SSI-learning in regard to each dimension of perception.

### *5.6.1 SSIs and students' experiences of the contextualised biology learning*

The first important finding of this research is that the socio-scientific issues (SSIs)-based instruction implemented in this research is perceived as a new experience for Indonesian secondary school students. According to the cross-cases analysis, it is revealed that, besides being expressly stated as a 'never-experienced' learning pattern (e.g MpS-II (1)), students also quoted that SSI-based learning in which they were involved was an unusual learning environment. These findings are consistent with an initial review of the literature prior to this research that there was only a very limited number of research studies about SSI implementation in science education classrooms in Indonesia (e.g Herlanti, Rustaman, Rohman, & Fitriani, 2012; Subiantoro, Ariyanti, & Sulistyo, 2013). However, those quotations are only a part of students' perceptions of the SSI-based learning particularly for the meaning of contextualisation of SSI.

Given the enthusiasm showed by students through the interviews as well as being illustrated from the learning activities, the SSI-based lessons experienced by each group of students provided a useful vehicle for students to meet the contextualisation of the biology topic being learnt. Viewed as 'interesting', 'easier' and 'challenging', a useful meaning of SSI to contextualising the instructional topic was exemplified by students. Thus, an essential view represented by students' statements is a daily-life context reflected from the issues to which students are attracted, feel that the topic is easy to understand and encouragement to be involved in the lesson.

Recalling students' previous learning experiences showed a possible factor that might influence their perceptions of SSI lesson. There were very limited occasions in their lesson which provided students to view their biology topic within social perspectives. Thus, this represents a lack of experience with the socially-emphasised contextualisation of a biological topic which they had learnt. In contrast, participating in the SSI-based lesson allowed students to consider not only the biology knowledge of the issue but also social and ethical dimensions of the topic. Therefore, this finding supported a key principle of SSI in science education

practice which sets it apart from Science-Technology-Society (STS) education (Zeidler, Sadler, Simmons, & Howes, 2005).

The way in which SSI could engage students to confront their science knowledge and social-ethical considerations accommodated students in negotiating the issue from multiple perspectives, either with personal or social consideration. This dynamic interaction for a meaning-making process is another key function of SSI-based lessons (Zeidler & Nichols, 2009) that was also represented by the findings of this research. According to situated learning perspectives (Sadler, 2009), a meaning-making process possibly occurred in learners' mind when there is no separation between what is being learnt and will be understood within the environment in which the objects or problems take place. Furthermore, it should be noted here that, based on a social constructivist perspective, that the meaning-making process requires participation activities in a social environment that involves understanding the values and culture held by the community members.

### *5.6.2 Student involvement in the SSIs-based lesson*

Reviewing classroom scenarios by which the SSIs-based instruction was implemented in this research may illustrate the degree of student involvement in the classroom activities and how they perceived their learning atmosphere. An illustration from the beginning of the instruction for student of SMAN 11 Yogyakarta, for example, represented a low level of students' involvement as they faced a new situation regarding a topic in which a SSI (i.e. issue of mobile phone and society) was provided by the teacher. However, this perception was changed after students were encouraged to involve in group work activity. There were various extents to which the students perceived the group discussion in which they participated in positive ways. Based on the cross-case analysis, three dimensions of the groups' positive environment are revealed.

The *first* dimension is an increased engagement in providing ideas or opinions during the discussion. Students showed their motivation when being involved in

group activities and this supports the view of this first dimension. Dealing with group discussion, it should be noted that students have had experience in such activities in their previous learning experience, but there was a distinct group atmosphere developed during this research. As reflected by the excerpt MpS-III (3, 4) or MpS-VII (5), for instance, it is revealed that previous students' group-activities experiences did not engage them in any dynamic involvement. However, regardless of the way in which the teacher of each group of student managed the group activities in his/her biology classroom, the SSI-group discussion in which students were involved and implemented in this research showed a valuable meaning of the group activities toward students' enthusiasm for exploring as well as sharing their ideas or opinions.

Besides strong engagement of the sharing idea or opinion, group-mate social interactions occurred as *the second* dimension of the group positive atmosphere which might imply mutual advantage as well as interdependency amongst group members. Quotes BFM-III (3), MpS-VIII (5, 6), HDW-II (6), HDW-VI (3, 4), for instances, are explicit evidence of students' views on perceiving the advantages of the SSI-group activities for social interaction awareness in which they were involved. However, it cannot be denied that, to some extent, a few students preferred to be passive and even did not want to provide his/her idea or opinion during the discussion (e.g quote BFM-IV (4), HDW-IV (2)). Nevertheless, it can be pointed out that, as described previously about the dimension of engagement, some group members were motivated to share their ideas and opinions toward the issue. Students perceived that the variety of the shared ideas or opinions were valuable for them in making decisions and this would not have emerged if group-mate interaction was not sufficiently developed.

Following the two dimensions described above, various ideas occurred during group discussions for resolving the issue that revealed the *third* dimension of the group positive atmosphere. Students perceived that the way they dealt with different opinions provided by group mates as a challenging activity which might influence their involvement in the SSI-group discussion.

Those three dimensions are related to each other and underpin students' perception of their SSI-group activities. Dealing with the dimension of engagement to provide ideas or opinions, an expectation of group member involvement represents its association with the dimension of group-mate social interaction. This was perceived as productive discussion as, for example, represented by quotes BFM-III (2): *"… it was not good to make a discussion if not all students were involved"*. Two concerns arise, then, not only about the engagement and group member relationship, but also to look carefully at the degree of opinion as well as the way students confirm the different ideas that occurred during the discussion. Quotes such as MpS-IV (2): *"… I was challenged to make it better. But, on the other hand, I must have a strong basis of opinion. …"*, reflect the concern from a personal consideration, whilst quote BFM-IV (2): *"… It should not be like that. It was supposed to show better idea so that could make us consider. …"*, reflects the concern based on group awareness. These research findings considerably corroborate the valuable role of the SSI-group activities where students in all classes involved feel enjoyment with increasing motivation and getting friends' help reduces the learning difficulty (Tal & Kedmi, 2006).

### *5.6.3 SSI-learning objectives*

Considering the learning objective as a substantial component of science teaching and learning practice, the SSI-learning objectives which could be achieved by students are revealed and represent the functionality of the SSI-based lessons implemented in the research. These objectives include performing responses to multiple perspectives, which generate an insightful view of the issue and related-values of science and technology considerations, and communication skills.

The group discussion, as shown on BFM-II or some other quotes, represents a distinct perspective on how student responded toward the issues being discussed. Supporting personal intentions emerged in the group discussion (excerpt BFM-II), when students also considered other aspects such as economic, religiosity, and personal mother-baby relationship that were particularly mentioned for the issue of

breastfeed vs formula milk. Economic, social, political and ethical considerations also occurred when students were responding to the issue of hotel development and water sustainability and also for the issue of motorcycle driven by students.

Supporting the first part of the discussion regarding students' experience of the contextualised biology learning, knowledge particularly about the nutritional content of breastmilk and formula milk and their importance to the baby's health was perceived as part of the knowledge that could be obtained. Strengthening these aspects of knowledge and contextualisation, a view on the value of science-technology development was also perceived as one of the SSI-learning objectives. Another SSI-learning objective that was perceived by student involves communication skills which is mainly emphasised on the affective dimension in regard of the respect to others' idea and the way of delivering opinions in group discussion.

### *5.6.4 Students' attitude toward SSI-lesson*

As an essential dimension of the students' perceptions of SSI-based instruction, attitude toward SSI-lesson has been a substantial concern in a number of studies (e.g. Feierabend & Eilks, 2010; Ottander & Ekborg, 2012; Morris, 2014). With various aspects of attitude reflected by those research, this research also found similar features of attitude expressed by the participants. The representations of the philosophical perspective of SSIs and its role for contextualising science topics reflected on the first discussion may lead the way for students to develop their attitudes toward SSI in their biology classrooms. This attitude is supported by some data which represent students' views especially of their roles in SSI-activities. These include: a responsibility to make a good decision and seeking appropriate information toward the issue, commitment to SSI-discussion, the way in dealing with others' idea or opinions, and the quality of arguments that was delivered by in group discussion.

In addition, students also perceived the way their teachers performed their roles in their biology classrooms. The data showed a distinct perception expressed by the students in dealing with the difference in the learning environment which the SSI-based instruction is more likely preferable for students. However, regarding biology learning strategy, there is an interesting fact that was revealed by the excerpt BFM-VII (1), where a student stated that preferred to learn through the usual way her teacher managed the instruction.

The research findings considerably highlight some essential points revealed from previous studies. Regarding students' roles in SSI-activities, these corroborate what Tal & Kedmi (2006) and Lee et al (2013) previously stated that learning SSI in groups could potentially increase students' motivation as the group activities may provide enjoyable situation. Moreover, in SSI-group activities it is possible for student to strongly engage in the discourse of SSI, freely to express their considerations, and support each other to solve the problem with feeling of responsibility and willingness to act. These findings are likely in alignment with a study by Topcu (2010) which developed an instrument for attitude toward SSI with three main dimensions, including: interest and usefulness of SSI, liking of SSI, and anxiety towards SSI. Furthermore, according to Tal & Kedmi (2006), the data could represent the dimension of classroom culture with an involvement of teaching strategies managed by teacher and the preference of learning style perceived by students. Thus, the data of the research support the research output which showed that attitude toward SSI-lesson as one important aspect of students' perception of SSI-based instruction.

### *5.6.5 Special findings: apart of the Self-regulated learning perspective*

Although in limited degree it is interesting to find that students' perceptions of SSI-lesson are very likely to reflect the self-regulated learning perspective (Boekaerts, 1999). The stated perceptions, such as BFM-V-C (5), MpS-IV-Mar (5), represent at least two aspects of the perspective, including a view of an ideal way to reach

expected SSI learning achievement and a critical view of an appropriate learning environment in biology classroom.

The former view especially reflects a particular condition as well as activities needed by students for obtaining related knowledge or skill during SSI-lesson, as asserted by statement such as: *"We need to seek supportive information"* (excerpt BFM-V-C (5)), or *"We needed more information on the proof of nutritional content [of formula milk] as well as its hygiene"* (excerpt BFM-VI-S03-B (6)). These show the meaning of relationship between learning pathways or activity required (i.e. seeking supporting information) with the expected learning objective that is perceived by students.

Regarding the learning pathways, there is an extent to which the appropriateness of SSI-learning environment is also considered as an important factor that might influence student learning style and learning achievement. Reflected by quote BFM-I-Lrs (2) or BFVII-Nik (1 & 2), for example, a critical view of whether the learning environment managed by the teacher is appropriate for student needs or satisfaction regarding learning objectives that can be obtained affirms the second view.

Those two views of ideal way to reach expected learning achievement as well as critical view of SSI-learning environment in biology classroom represent a key aspect of the self-regulated learning. According to Boekaerts (1999), the dimension of the self-regulated learning is related to a choice of alternative learning style that is suitable for a specific task or learning problem. Moreover, according to Butler and Winne (1995), those views also considerably show a feature of self-regulated student who is enabled to make a reflection on and aware of the quality of his/her self-engagement in learning activities, in regard to knowledge, belief, motivation, and cognitive process.

An emergence of the dimension of self-regulated learning perceived by students as special finding of this research could be interpreted in, at least, two points of view. First, as figured out in in Chapter 4, there is no certain scale (or items) of the self-regulated learning dimension constructed in the developed instrument of student

perceptions of SSI-based instruction. It means that the dimension was not intended to be examined through the questionnaire and this might has been a weakness or limitation of this research. However, as the dimension represented through the interviews, it could be highlighted that SSI-learning is likely a potential to provide an occasion to accommodate students reflecting their learning style or pathway and reviewed its advantage or disadvantage for expected learning achievement. Perhaps, in a limited degree, this second point of view may support or in alignment with previous research about SSI-based instruction and its relation with self-regulated learning or metacognition perspective (e.g Eggert, et al, 2013).

# CHAPTER 6
# STUDENTS' INFORMAL REASONING REGARDING SOCIO-SCIENTIFIC ISSUES

## 6. 1 Overview

This chapter provides the answer to the third research question about students' informal reasoning regarding socio-scientific issues (SSIs): "*What types of informal reasoning can be performed by students based on SSIs-based learning?*".

Following the research methods described in Chapter #3, students' informal reasoning was examined using a monologue strategy (i.e., written form) with an informal reasoning sheet that was provided before and after the SSIs-instruction for each group of students. This pre- and post-learning approach was not intended to examine the effectiveness of the SSIs-based instruction. Rather, the written informal reasoning expressions that were provided by students was the unit of analysis of the research.

A qualitative analysis approach, which was mainly based on the framework developed by Sadler and Zeidler (2005), was used to determine the characteristics or patterns of the informal reasoning generated by students. Based on this framework, students' answers could be defined as intuitive, emotive, rationalistic, or integrated.

This chapter encompasses mainly the two following sections. First, it elaborates the analysis of students' informal reasoning from the informal reasoning sheets. To make this section readable, it is presented in the following outline:

1) Every SSI is classified as a base of the data presentation and mentioned firstly as a sub-section (e.g., 6.2.1 Issue #1: …). Therefore, there are four main sub-sections that precede this first section based on the socio-scientific issues which were implemented in this research. A brief description about each issue is stated

to provide a general introduction about the controversial problem that was presented to the students.

2) On the basis of pre- and post-instruction episodes, data of students' informal reasoning is presented for each issue and class. To show the extent to which each pattern of reasoning is expressed, some students' answers are provided as representative of the reasoning pattern, either intuitive, emotive, rationalistic, or integrated pattern, observed across the data set.
3) It should be advised that any student's answer or statement which represents a certain pattern of informal reasoning provided in the pre-instruction result, may or may not change to other pattern in post-instruction findings. Therefore, a possibility of the change of student's informal reasoning is further recognised.
4) To recognise changes in the patterns before and after a SSIs lesson, every student's statement is marked with a quotation number and student number-code. Quotation numbers are stated in sequence throughout the section. On the other hand, the student number-code will always be same for a student who expressed an answer. However, it should be noted that the student's number-code will only be used for students from the same school under the same issue. For example, for the issue #1 and from SMAN 2 Bantul, Quote #1 (S24) means that it is the first quotation in the section which was written by student 24 before participating in the SSIs lesson. Quote #4 (S24) shows the reasoning pattern which was expressed by the same student (S24) after the SSIs-instruction.
5) A brief explanation is given for the examined informal reasoning for every pattern of reasoning and issue in the discussion section.

The second part of this chapter provides a discussion of the research regarding students' informal reasoning based on the data provided in the previous section. Despite presenting separately for each SSI and group of students, the discussion will integrate all issues as well as groups of students in order to generate a comprehensive understanding towards the research objective.

## 6. 2 Student Informal Reasoning based on the Issue Discussed

### *6.2.1 Issue #1: Breastfeeding vs formulae; Is a doctor's note required?*

The issue focuses on a mother deciding whether she will breastfeed her child or give infant formula to her baby. This is a controversial issue that has been much discussed in Indonesia in recent years. To engage students on this issue, a specific scenario was generated and provided to students by asking about a formal requirement that needed to be considered by a mother who is willing to give her baby infant formula. Therefore, this issue was stated and then provided in the informal reasoning sheet:

*"Attempts to promote a breastfeeding program by the government in Indonesia may be challenged by infant formula milk products that influence mothers who prefer it as a breastfeeding substitute. To ensure that the breastfeeding program is successful, do you agree that consumers who intend to purchase infant formula milk for their baby are required to have a doctor's note? Support your answer or opinion with reasons".*

**Before instruction**

The first thing that could be noted from data of students' informal reasoning regarding the issue is, before the instruction, there is no student's answer that can be defined as intuitive pattern. On the other hand, of all students' answers, only one could be categorised as emotive reasoning, by this following quote:

Quote #1 (S29):
*"Agree, because although it might be expensive, formula milk does not mean necessarily good".*

According to quote #1, student express his/her agreement by underlying it to an awareness of the appropriateness of the formula. However, instead of looking at a nutritional factor or health aspect, for example, student was more likely to provide a support idea based on economics aspect in terms of the price of the formula. The

answer asserts that no matter whether the formula is expensive, it is not necessary to be given to the baby. Thus, without any rationalistic basis, this answer is considerably related to emotive reasoning. By comparison, the following quotes represent students' responds which can be defined as rationalistic pattern.

Quote #2 (S2):

*"Agree, because there would be some nutrients in the formula milk which are not appropriate with the baby's needs. Therefore, the doctor's note is important to ensure for baby's health"*

Quote #3 (S17):

*"Agree, consider how important breastfeeding for baby is, as it is useful for the baby's immunity"*.

The main point represented in the quote #2 is that it focuses on appropriateness of nutrients' suitability provided by the intake that will affect baby's health. Regarding baby's health, another answer that is represented by quote #3 supports the previous view by pointing out the advantage of breastfeeding for baby's immunity. These views of advantages underlie the agreements with the doctor's note which was primarily stated by the students. Thus, unlike the emotive reasoning illustrated by quote#1, these answers represent the rationalistic informal reasoning given by students.

Besides responding on the basis of a single pattern of informal reasoning – emotive or rationalistic reasoning – some students used a combination of such single pattern as shown by the following statements. Therefore, the following answers indicate integrated reasoning performed by students.

Quote #4 (S5):

*"Agree, as a baby should be breastfed as the milk contains important and perfect nutrients [for babies]. Besides, breastfeeding is also the best medium for a mother-and-baby relationship. It is assumed that a non-breastfed baby does not have an emotional closeness with the baby's mother. Moreover, a breastfed baby could have auto-immunity"*.

Quote #5 (S11):

*"Agree, as breastfeeding is much better. It has more complete nutrients rather than formula, despite it could build mother – baby emotional relationship. There is no reason for not breastfeeding. In case the mother works [so she cannot give breastfeeding], breast milk could be stored and sterilized before providing to the baby. And if the mother is naturally unable to breastfeed, the baby could be breastfed by a foster mother like happened to Prophet Muhammad.*

The above quotations could be defined as integrated reasoning as these expressions relied on more than one orientations. Both quotes #4 and #5 are categorised as emotive-rationalistic since students S5 and S11 based their reasoning on two different orientations including the breast milk nutrients aspect as a rationalistic view and the mother-baby relationship as an emotive consideration.

**After instruction**

Whether students changed their reasoning after participated in SSI-lesson could be recognised from their informal reasoning responses after the instruction. For instance, student S29's answer, which was previously based on emotive reasoning before the instruction, can be defined as rationalistic after the instruction, as reflected by the quote #6 below:

Quote #6 (S29):

*"Agree, as not all babies need the same nutrients. There is a possibility that a baby is allergic to product 'A', thus, the doctor can advise which formula product that is appropriate with the baby's needs. Faults in choice may interfere with the baby's growth".*

Different to his/her previous answer, the agreement provided is mainly based on the consideration of nutrient suitability of formula to baby's health issue. From this health risk perspective, student S29 had responded to the issue with a rationalistic reasoning, and, it means that student S29 changed his/her reasoning from emotive pattern before SSI-lesson into a rationalistic one after the instruction.

From similar perspective on health risk, student S2 and S17 kept their reasoning as rationalistic after the instruction, as reflected by quotes #7 and #8 as follow.

Quote #7 (S2):

*"Agree, for babies' health and to know the appropriateness of preference formulae, therefore to avoid something wrong like allergies".*

Quote #8 (S17):

*"Agree, for baby's health. Without the doctor's advice, some mother may misjudge the product [of formula], and if not appropriate, the baby may get sick".*

Supporting the view of breastfeeding advantages, quotes #7 and #8 represented that the aspect of risk (of the formulae) that underlies students' (S2 and S17) reasoning. Potential allergies or health problems due to incompatibility of formula contents, which were stated by the quotes, evidently reflect the risk consideration. These responds could be defined as rationalistic and, therefore, imply no change of reasoning pattern by these students.

Reviewing the following answers may inform whether students S5 and S11 who previously responded the issue with integrated perspective changed their reasoning.

Quote #9 (S5):

*"Disagree, as getting the note will take time and money, and this complicates the low-income mothers. It has been hard to buy the product [formula], even less for getting the note. It would be better if this program is rejected, as it is troublesome, waste of time and money. Consumers have their own right to choose the preferred product".*

Quote #10 (S11):

*"Agree, for baby's welfare and health, so there is no mistake on formula consumption".*

Like other single pattern responses, the integrated reasoning expressed by students were also changed after a SSIs-lesson. Student S5, for example, whose answer was previously stand on appropriate nutrient as well as mother-baby relationship considerations before the instruction, then provided an answer that more likely

stand on social needs only. Phrases: *"… and this complicate the low-income mothers. … Consumers have their own right to choose the preferred product!"* considerably indicate the focus of the answer on people interest as well as empathy. Thus, this answer could be recognised as emotive reasoning. Like student S5, student S11 also changed his/her answer into a single pattern of reasoning. Emphasizing the answer on baby's health issue regarding the milk intake with no other consideration, student-S11's answer then could be defined as rationalistic.

### *6.2.2 Issue #2: Mobile phone and society; Should free wifi be restricted?*

The rapid development of communication technology that has resulted in a variety of devices as well as a wide range of facilities, such as smart phones and wireless networking ("wifi") make it easy for people to do particular activities related to information seeking and sharing. On the other hand, although it is still debatable, there is a critical issue concerning the habit of people using their mobile phones nowadays despite the risk of electromagnetic field exposure emitted by the device and the supporting facility (i.e., wifi). It seems that people are not aware about the risk and this becomes a controversial and interesting issue to be learnt in the biology classroom. Therefore, this research presented the issue to students from the following standpoint:

*"Concerning the possible health issues regarding mobile phone usage and wifi facility in our society, do you agree that the free-wifi facility in public spaces needs to be restricted? Support your answer or opinion with reasons"*.

It should be noted that since there were two teachers from different schools who taught this issue, the students' informal reasoning data will be presented in two parts, firstly from SMAN 11 Yogyakarta and followed by the data from SMAN 1 Kasihan, Bantul.

**School: SMA 11 Yogyakarta**

**Before instruction**

A very small number of intuitive reasoning were expressed by students for this issue before SSI-lesson. As shown by quote #11, for instance, a simple-and-immediate response that was expressed by student S9 represents its feature as intuitive reasoning.

Quote #11 (S9):
*"Agree, so we will not be addicted to the internet"*.

The quote #11 shows a specific feature of intuitive informal reasoning as it indicates an immediate expression with no more explanation or supporting argument for student S9's answer. It is not clear for something that might be an implication of being *'addicted'*. However, of other students' answers there are some that have different feature and could be represented as emotive reasoning, as shown by the following quotes:

Quote #12 (S4):
*"I do not think the policy can reduce the impact or risk [of EM radiation], as whether the wifi is provided or not, it does not influence people using their device. For example, when an individual is playing a game [with the device], it is not necessary to use wifi and he/she may still play the game for a long time"*.

Quote #13 (S17):
*"Disagree, I do not think that the restriction will stop the risk of EM radiation, because each individual still can use his/her device on their own"*.

The above responses could be defined as emotive reasoning as these are based on people's interest as well as the habit of the use of mobile phones. Such statement: *"… it is not necessary to use wifi and he/she may still play [an online] game for a long time"*, or *"… … each individual still can use his/her device on their own"*, reflect a view on peoples' personal intention *on using their mobile phone on their*

*own*, that considerably figure out the personal-emotional motivation. Therefore, these answers can be recognised as emotive informal reasoning.

Apart from intuitive and emotive patterns, students' informal reasoning also occurred and could be defined as rationalistic as quotation below illustrates:

Quote #14 (S23):
*"Agree, as EM radiation is really harmful for our health"*.

The quote that explicitly state a hazard of EM radiation indicates the disadvantages or the health risk regarding *wifi* (and mobile phone usage) that was expressed by students before the instruction. As the risk or disadvantage underpinned the answer, thus this quote could be categorised as rationalistic reasoning.

One thing should be noticed from the data gathered is that students looked more intent on responding to the issue through diverse perspectives, and these following quotes represent students' reasoning before SSI-lesson.

Quote #15 (S6):
*"Public wifi should be reduced as it could drive addiction [on internet] and hazard from its EM radiation. But economically, the facility usually attract customers. In my opinion, awareness about EM radiation risk needs to be given to the customers or society so they can reduce their habit of using the internet or device"*.

Quote #16 (S27):
*"I disagree, because in this modern era, wifi facility is an important thing in daily life for supporting our activities, news update, and entertainment. If there is a restriction, it will be a nuisance. Regarding the radiation problem, in my opinion, every person has to consider as well as limit their own self, as only they understand the risk"*.

According to those quotes, it could be recognised that a fusion of some aspects such as people's habit of using mobile phones, the risk of radiation, or social or economic interest, are orientations that are used by students to make their decision. Therefore, these answers considerably reflect integrated stand point of informal reasoning.

**After instruction**

Reviewing students' answers stated after SSI-lesson shows a trend of change of the students' informal reasoning. The following quotations represent the answers from similar students who were previously mentioned earlier.

Quote #17 (S9):
*"I disagree, as wifi use depends on each user"*.

Based on quote #17, it is shown that student-S9 changed his/her decision after SSI-lesson. Whilst his/her answer before the instruction was 'agree' (to the standpoint of the issue), it changed to 'disagree' after the lesson. However, if the before-lesson answer could be defined as intuitive as it immediately stated and has no supporting argument, the after-lesson answer is likely show a similar pattern as intuitive. Perhaps the answer implicitly reflect a potential implication in regard of people intention or motivation of using the wifi, but as there is no supporting argument that clearly explains 'something might be occurred from *depends on each users*', the answer looks like still on its pattern as intuitive. Thus, it is considerably noticed that in the case of student-S9, there is no change in his/her reasoning between before and after the SSI-lesson.

On the basis of people interest or motivation, informal reasoning that were provided after SSI-lesson by students S4 and S17 feature a similar pattern compared to the before-lesson answer, as represented by the quotations below.

Quote #18 (S4):
*"I disagree, because everything depends on each individual and the main factor of EM radiation is phone utilization duration, regardless using wifi or not"*.

Quote #19 (S17):
*"I disagree, no matter whether there is wifi or not, people will still use their own mobile phones. Perhaps what we need to do is reduce the intensity of using mobile phones rather than restricting wifi in public spaces"*.

Those students' responses reflect that their decisions toward the issue made after SSIs-learning emphasized on personal factor of mobile phone use. The quotes show the way students view that, regardless of *wifi* availability, individual motivation and habit are the main factors for mobile phone use. Instead of the wifi accessibility, the duration of mobile phone use habitually spent by people is suggested as a factor that potentially lead to EM radiation. As these reasoning are based on personal interest or motivation so that they could be defined as emotive informal reasoning pattern.

The extent to which students keep their orientations or perspectives to respond the issue after participated in SSI-lesson is also shown by student whom the answer is in rationalistic pattern. The following statement represents this trend.

Quote #20 (S23):

*"I Agree, electro-magnetic radiation will be radiated everywhere because of so much wifi usage. It is better to only provide wifi in specific places".*

According to the quote #20, student S23 consistently stood on a same point of view to respond the issue. The risk of electro-magnetic (EM) radiation that is potentially emitted by the wifi was explicitly stated and emphasised in his/her answer. Thus, like his/her answer before the SSI-lesson, this one which was provided after the instruction could still be defined as rationalistic.

An extreme distinction of students' informal reasoning compared to before SSI-lesson occurs in answers stated by S6 and S27 after the instruction.

Quote #21 (S6):

*"I disagree, everything starts from each individual. Therefore, it is necessary to inform people about the impact of EM radiation that is radiated by mobile phones so they will aware about it."*

Quote #22 (S27):

*"I agree to a restriction, as it involves electromagnetic radiation. A long exposure may cause cancer and cells damage".*

Whilst before the lesson S6 responded the issue with an agreement (toward the policy) and his/her reasoning stand on emotive-rationalistic pattern, on the other hand, his/her answer after the lesson changed into a disagreement. Regarding the orientations that underpinned his/her decision, it is reflected that personal concern considerably underlies the answer as *"…everything starts from each individual. …"*. Moreover, student S6 also supported his/her point of view by looking at the social responsibility that is necessary undertaken by *"… … inform people about the impact of EM radiation. …"*. By this answer it is obviously shown that student-S6's reasoning has changed from integrated pattern (emotive-rationalistic) before the lesson toward mostly emotive pattern after the instruction.

Similar to student S6, student S27 also changed his/her answer toward the issue. Before the SSI-lesson, he/she decided to disagree toward the policy and his/her reasoning was recognised as emotive-rationalistic. But after the lesson, it is stated that his/her point of view focuses on a high risk of EM radiation potentially emitted by the wifi. Thus, this answer after the lesson indicate the change of his/her informal reasoning from integrated pattern toward a rationalistic one.

**School: SMAN 1 Kasihan, Bantul**

**Before instruction**

Like in the former class, a limited number of intuitive reasoning patterns that were expressed by students in this school were characterised by an immediate expression, as shown in quote #23 which was expressed before instruction.

Quote #23 (S6):
*"I agree, it is better to limit the time usage"*.

The quote #23 stated by student S6 considerably represents an intuitive reasoning as it has no further explanation that might show the implication of such decision made. The implication maybe like, for example, whether the time of limitation will affect the length of people using internet and mobile phone so that people may face

a low risk of the applications. Thus, the feature of an immediate respond with no supporting argument makes this quote stated by student S6 characterised as intuitive informal reasoning.

Students' responses to the issue before participating in the SSIs-instruction also revealed for emotive reasoning, and this can be viewed in the following quotes.

Quote #24 (S7):

*"I agree with a restriction, for lessening wifi and device addiction so people will using their device only as much as they need"*.

Quote #25 (S21):

*"It [wifi facility] absolutely needs to be restricted. However, for some places, such as schools, it should not to be so, as it is important for the school community, especially for students to look for references. For shopping centres, on the other hand, it needs to be restricted, to support individual interactions"*.

These quotes show that the need of using internet facilitated by wifi for the society is the main background of students' responses. Preventing addiction of wifi as well as mobile phone use is emphasized by student S7 to make an agreement toward the issue. Although having similar point of view on the importance of wifi facility, however, student S21 thought particular condition in making his/her decision especially about the place and those who will use the facility. However, both answers based their decision on people or social interest with an empathy and thus could be categorised as emotive pattern.

With different perspectives, the extent to which students' reasoning before SSI-instruction also could be defined as rationalistic, as represented by the following excerpts:

Quote #26 (S18):

*"I agree to reduce the effect of EM radiation. Limitation of wifi will lead to lessening of mobile phone use, thus the risk can be limited"*.

Quote #27 (S25):

*"Disagree to some extent. As EM radiation that impacts on our body basically originated from mobile phone utilization, not from wifi. Therefore, device application actually should be limited".*

It is explicitly stated that the basic orientation represented by students' responses was mostly on a consideration about the risk or impact of electromagnetic radiation. However, although based on a similar basis, each student provides different point of view. Whilst student S18 supported the policy (of the issue) with an agreement as *"… [the] limitation of wifi will lead to lessening of mobile phone use, thus the risk can be limited",* on the other hand, student S25 considered the primary source of the radiation (i.e mobile phone, instead of the wifi), so that he/she preferred to take another decision by *"… device [mobile phone] application actually should be limited"*. Therefore, since the answers relied their decision on the risk issue, both then could be characterised as rationalistic informal reasoning.

Like students in the former school who learnt the same issue, some students in this school also provided their answer that could be defined as integrated reasoning. The following quotations represented such reasoning that was made by students before participating in SSIs-learning.

Quote #28 (S11):

*"I disagree for the restriction. I do not think wifi causes health risks. The restriction is unnecessary to be applied because the risk is actually from mobile phone use, and it is a personal business. Wifi does not produce radiation that harms our body. Otherwise, it should be provided more in public spaces for more advantages".*

Quote #29 (S15):

*"I agree, besides reducing its [wifi] radiation to our body, the restriction can also lessening internet misuse, like accessing pornography or cybercrime".*

According to the quotes, students reflected that the risk of electromagnetic radiation and peoples' interest may combine their perspective and drove their reasoning with integrated expression, especially emotive-rationalistic patterns, but in a distinct

decision. From student-S11's answer, for instance, he/she provided two sides point of view where social interest is mostly considered than the health risk of EM radiation so that he/she decided with a disagreement toward the policy. On the other hand, with similar basis of the risk as well as social value, student S15 made an agreement toward the policy. However, it is considerably shown that both answer are characterised as integrated reasoning pattern.

**After instruction**

Reviewing students' answer after participating SSI-lesson will show whether the pattern of informal reasoning expressed by students are changed. First, from student S6's answer who previously expressed an intuitive reasoning before the lesson.

Quote #30 (S6):
*"I agree, wifi restriction may lead to limit the mobile phone usage"*.

According to the quote, the answer is likely has similar way with the before-lesson answer in representing a simple view about the limitation of mobile phone usage as the main orientation toward the issue. Moreover, like previous reasoning before the lesson, the answer has no more explanation about the implication that might occur from the idea of 'limitation of the mobile phone usage'. This represents an immediate respond toward the issue and, therefore, shows an unchanged reasoning pattern expressed by student S6 after a SSIs-lesson as intuitive reasoning.

An interesting fact emerged regarding students' responses which previously defined as emotive pattern like the following excerpts.

Quote #31 (S7):
*"Agree, so people will not be getting addicted to their phone device. The restriction may also improve quality time as people can utilize their time better instead of interacting more with their phone devices"*.

Quote #32 (S21):
*"I agree with the restriction to reducing the impact of EM radiation to our body"*.

Based on the excerpts, the answer expressed by student S7 is still as emotive after the instruction. The agreement provided toward the policy is supported with an argument about an advantage of wifi restriction for social values (i.e. social interaction with others rather than with their device). Social consideration that was emphasised by student S7 reflects that the pattern of informal reasoning expressed can be defined as emotive pattern.

If student S7 kept his/her reasoning as emotive, a different reasoning provided by student S21. Underpinned his/her answer on the basis of the risk of EM radiation awareness, it is considerably shown that student S21's answer can be classified as rationalistic pattern. This means that the pattern of informal reasoning performed by student S21 is changed from emotive pattern before SSI-lesson to a rationalistic one after the instruction.

An extent to which rationalistic reasoning pattern is likely more firm might be represented by the following statements which are provided by students:

Quote #33 (S18):

*"I agree, to reducing the impact of EM radiation. With the restriction, mobile phone use may also be limited so the risk will be decreased.*

Quote #34 (S25):

*"Agree to the restriction, to limit the use of mobile phone so the exposure of EM radiation to our body can be reduced".*

Both students S18 and S25 are those whom the previous reasoning before SSI-lesson are rationalistic pattern. Reviewing their answers after instruction indicates a strong consideration of the risk as well as the impact of EM radiation caused by the use of wifi. It is explicitly stated that their agreement toward the restriction policy may lead to limitation of mobile phone use and reducing the health risk of radiation. These arguments considerably represent rationalistic reasoning and, thus, mean that students' reasoning pattern did not change after the SSIs-lesson.

A view on relationship between wifi, mobile phone use and the health risk caused of radiation also underlies students' responses whose answer previously integrated pattern before SSI-lesson. However, an extent to which a change of each of their reasoning results in different way, as represented by the following excerpts:

Quote #35 (S11):

*"I disagree, because how much risk will emerge depends on the extent of mobile phones usage".*

Quote #36 (S15):

*"It is unnecessary to be restricted. Because today students are encouraged to interact with the internet for personal learning. Regarding the risk of radiation, it can be reduced with utilizing the device and wifi appropriately".*

According to student S11, it is suggested that the degree of health risk of radiation is mainly influenced by mobile phone use, instead of by the wifi. This argument led him/her to make a disagreement toward the restriction policy. On the similar basis of the use of mobile phone, student S15 also disagreed with the restriction policy. However, his/her decision is supported by a consideration on people (i.e. students) need especially for learning purpose and this is emphasised by student S15 to underlie his/her decision. Therefore, according to these different answers it can be pointed out that after SSI-lesson, student S11 changed his/her reasoning as being rationalistic pattern whilst student S15 stood on the similar pattern like before the lesson as integrated one.

### *6.2.3 Issue #3: Motor cycle driven by students; Should it be banned?*

It was reported by a local newspaper, that the number of motor cycles in Yogyakarta region, Indonesia, increased by 15% each year. What is an interesting phenomenon is the fact that most of the vehicles are driven by secondary school students. As the vehicles use fossil fuel (i.e., gasoline) and emit carbon dioxide, it means that driving a motor cycle is also contributing to increasing greenhouse gases. How students perceive themselves as contributors of greenhouse gases (and global warming) with

their preference for driving motor cycles is the core of the issue discussed. Thus, the issue was formulated as:

*"Considering that one of the most motor cycle drivers in Yogyakarta are school students, do you think that for decreasing the greenhouse effect a regulation from the local government to ban motor cycles driven by students is required? Please support your answer or opinion with reasons"*.

**Before instruction**

In a very limited number, intuitive reasoning was expressed before the SSIs-instruction and was stated, for instance, by student S4 as follows.

Quote #37 (S4):
*"It is better to go by bike or be accompanied by parent"*.

This answer could be defined as intuitive because it shows an immediate expression with a simple view expressed by the student. Like previous issues, this answer is likely not showing a strong decision as it has no argument that might explain why *'it is better to go by bike or be accompanied by parent'*.

On the other hand, specific views that were reflected by the following quotes, for instance, suggest the quotes being recognised as emotive reasoning.

Quote #38 (S17):
*"It does not need to be applied, since high-school students are not the only motor cyclists. Otherwise, the restriction should be applied for all motor cyclists"*.

Quote #39 (S19):
*"If the government wants to apply the policy, they should provide appropriate public transport. What we have now is not sufficient"*.

The views that were reflected by these quotes including people's interest and social value (or social justice) like in student-S17's answer, or government policy that is

represented by student S19, considerably underlie the decision made by students toward the issue. Thus these quotes are defined as being emotive.

Besides intuitive and emotive patterns, rationalistic reasoning responses were also used by students before instruction. The following excerpts represent the pattern of students' reasoning.

Quote #40 (S16):

*"It should be applied. Otherwise, there will be more students driving motor cycles, and more greenhouse gases will be produced"*.

Quote #41 (S22):

*"Yes, it is needed. It is better to take public transport for reducing greenhouse gases"*.

Focused on the risk aspect of the issue such as more motor cycle driven by student means more greenhouse gases produced (quote #40), or an alternative way given to reducing the greenhouse gases emission (quote #41), obviously show that these answer are relied on rationalistic consideration.

Considering a distinct situation in which many aspects need to be taken into account led students to use various orientations when making decisions about the issue through integrated reasoning. An excerpt below represents the orientations were expressed.

Quote #42 (S14):

*"The rule needs to be applied to reduce the greenhouse effect. However, if students have to do so [driving motorcycle], maybe it is occasionally allowed"*.

Besides the effect greenhouse gases emission to the environment, people interest (i.e., students themselves) is a condition that was taken into account in student-S14's answer. This represents two bases of reasoning which underpinned the answer, including rationalistic and emotive. Therefore, student S14 answer can be characterised as integrated reasoning pattern.

**After instruction**

Reviewing students' answers after SSI-lesson shows the extent to whether their reasoning are changed. According to student S4, for example, whom the answer is intuitive before the lesson may represent the change, as stated in quote #43 below.

Quote #43 (S4):

*"I think it is better to have a restriction rather than a ban. For those who live no more than 5 km, they have to ride a bike. And if it is more than 5 km, they are allowed to drive a motorcycle".*

A reorientation after SSI-lesson undertaken by student S4 for his/her answer by which people's interest as well as condition is taken into account as the basis of reasoning could make the answer defined as emotive reasoning. This means student S4 changed his/her answer toward the issue compared to the before-instruction answer.

Unlike student S4's answer, the following excerpts which were expressed by student S17 and S19 show a different trend which were not change in their pattern.

Quote #44 (S17):

*"No, I do not think it [the policy] is required. The first thing that needs to be aware is to raise the awareness. Otherwise, it would not succeed. In addition, we need to control ourselves first, then we can induce others. People need vehicles".*

Quote #45 (S19):

*"If the condition is applied, it would be better if special modes which could reach remote areas are provided for students to get to school".*

These answers seem to affirm the orientations used by students which were likely unchanged after instruction where people's interest, government policy and social value mainly underlie students' responses. Therefore, these answers can be defined as emotive. However, there was limited extent to which students changed their rationalistic perspective into a different pattern after participating in the SSIs learning as shown by the statements that follow:

Quote #46 (S16):

*"It is necessary to be applied to reduce $CO_2$ emission".*

Quote #47 (S22):

*"Might be applied, but the government has to provide mass transport modes that are able to accommodate peoples' needs".*

Particularly in quotes #46 and #47, there is indication of a different orientation used by students in which social considerations (i.e., public transport requirement) led to their answers. However, it can be noticed that most of the quotes still took a rationalistic stand after instruction as the impact of $CO_2$ emission was emphasised by students to respond to the issue in regard to reducing the emission of greenhouse gases.

Whether students whom the answers are previously integrated in the pre-instruction still use these orientations after instruction can be reviewed in the following statements.

Quote #48 (S7):

*"Necessary to do, but there should be an appropriate supporting facility, such as school buses for students".*

Quote #49 (S14):

*"It is needed, but the government also needs to provide appropriate facilities as some students live in remote areas and their parents cannot accompany them to school. School buses should be provided by the government".*

Students' responses after instruction are likely to be still integrated as most of them agreed to the issue (i.e. an agreement of motorcycle restriction for students). Moreover, they also provided provisions regarding the agreement which mostly are in respect of people's (including students themselves) interest.

### *6.2.4 Issue #4: Hotel development and water sustainability; Should the development be limited?*

A massive property development, especially building of hotels, in the Yogyakarta region, Indonesia, is a controversial phenomenon that led to the issue being discussed in this research. On one hand, the development may support local economic development of the society, particularly regarding tourism. On the other hand, there is an environmental issue because the developed properties significantly decrease the natural groundcover in the region and may disrupt the water cycle since the natural groundcover plays an important role as a buffer system for the process of infiltration of water into the ground. Therefore, this natural groundcover area ensures the availability of groundwater for the ecosystem. However, if the natural groundcover is continually decreased due to the development, the water table may fall and so water is not much available.

This controversial issue was provided to students as follows:

*"The rapid development of properties particularly hotels in the Yogyakarta region may support the economic sector. However, on the other hand, the development may also impact on the water cycle disruption. To negotiate this issue, do you agree that hotel development in Yogyakarta should be limited? Please support your answer or opinion with reasons"*.

**Before instruction**

Quote #50 below, in particular, represents an instance of intuitive reasoning expressed by students before participating in the SSIs-instruction which looked like they were simply and immediately expressed with a lack of explanation.

Quote #50 (S5):
*"I agree, as infiltration areas are required"*.

The above excerpt reflects a lack of broader views held by students when dealing with the issues before instruction. Although the answer has an idea that underpins the main decision (i.e. the agreement), however, there is no further explanation that can clearly assert the relationship between the decision and the idea, and because of this the answer can be defined as intuitive reasoning.

Like intuitive pattern, students' responses which can be viewed as emotive occurred in a very limited number of cases, as represented by the following quote.

Quote #51 (S20):
*"I disagree, because hotels will lift up the economic level of the society".*

It is explicitly mentioned in the quotation #51 that an assumption of a particular situation influenced by the issue led students to provide the answer before participating in the SSIs-instruction that could be recognised as emotive. A notion of the economic improvement of society represented an empathy aspect of the issue discussed.

Further review on some other students' answers reveals that clearly accentuating the risks as well as disadvantages, quotations below represent the rationalistic pattern of informal reasoning that were expressed by students who responded to the issue before participating in the SSIs-lesson.

Quote #52 (S3):
*"I agree, as more hotels result to lesser infiltration area. It may cause an overload of rain water that cannot be infiltrated and lead to flooding".*

Quote #53 (S21):
*"I agree, because those developments will aggravate the city. Land will be reduced, more waste, more traffic, and reduced water resource".*

According to these excerpts, the environmental impact, such as *"…It may cause an overload of rain water that cannot be infiltrated and lead to flooding"* (Quote #52), or *"…Land will be reduced, more waste, more traffic, and reduced water resource"* (Quote #53), are the main points that could be viewed from the students' answers.

As the basis of their answers are clearly assert the environmental risk, therefore, the answer can be defined as rationalistic informal reasoning.

Even though limited on this issue, the integrated reasoning pattern expressed by student obviously reflects its characteristics by which a combination between intuitive, emotive and rationalistic pattern is used, as shown by the following excerpt.

Quote #54 (S6):
*"I agree. Though those hotel developments may provide more employment vacancies. But, it also will induce environmental problems, such as a lack of open-green area that is useful for reducing pollution".*

Above-mentioned quotes #54 represents an emotive-rationalistic perspective where social concern (i.e., employment vacancies) and environmental problems were involved and used by students to respond to the issue before the SSIs-instruction. Moreover, these perspectives are likely interrelated to support the main decision (i.e the agreement).

**After instruction**

Reviewing students' answers after SSI-lesson shows the extent to whether their reasoning were changed. For student S5 whom the reasoning previously was intuitive, for example, his/her answer was likely changed after the SSI-lesson, as reflected by quote #55 below.

Quote #55 (S5):
*"I agree, if there is no restriction, there will be no infiltration area".*

Represented by the quote #55 above, student S5's answers after the SSIs-lesson indicates a cause-and-effect perspective especially regarding the risk of the issue. Moreover, the risk represented by the answer considerably related to the environment aspect as *"… there will be no infiltration area"*. Because it has no

further explanation, therefore, this answer can be recognised as rationalistic pattern. It means that student S5 had changed his/her reasoning after the lesson.

Like student S5, a change of reasoning pattern is also occurred to student-S20's answer, as represented by the following excerpt.

Quote #56 (S20):

*"I disagree [to the developments]. Seems the developments can improve the economic situation, but does not the government consider commoners? It is tragic! Do not to let this city [Jogjakarta] become like Jakarta"*.

A distinct view is obviously provided by student-S20 as he/she has different decision compared to his/her previous answer. Furthermore, the decision is supported by two different perspectives. Firstly, an empathy toward commoners who might be impacted by the issue (i.e. hotel development), and secondly, an environmental disadvantage that implicitly presumed by *"… Do not to let this city [Jogjakarta] become like Jakarta"*. By this assumption, student expressed his/her worries if the city of Jogjakarta would be like the city of Jakarta (the capital city of Indonesia) which has a terrible environmental problem. Therefore, this answer represents a change of reasoning pattern which is performed by student-S20 to be integrated pattern after the SSI-lesson.

The trend of the change of reasoning pattern which has occurred above is unlikely applicable for student S3 and S21 whom the answer was previously rationalistic in pre-instruction. This can be viewed in the following quotes:

Quote #58 (S3):

*"I agree. If the development increases, the infiltration area as well as the water bank will be reduced"*.

Quote #59 (S21):

*"I disagree with the developments, as those can decrease water infiltration and induce flooding. In addition, some bad effects may also occur, such as congestion and air pollution"*.

Maintaining the orientation on the environmental consideration especially of water resource sustainability as well as the effect that might arise from the issue is the focus of students' perspectives as reflected by quotes #58 and #59 above. As similar views were also used by students before the instruction, this means that they did not change their reasoning pattern and keep those as rationalistic reasoning after the SSI-lesson.

The extent to which rationalistic informal reasoning is more likely used by students after SSI-lesson is also represented by the following quotes.

Quote #60 (S6):

*"Agree, as massive hotel developments may have a poor impact particularly on the environment. More congestion, a lack of water infiltration that further may cause flooding"*.

Quote #61 (S27):

*"I agree, because Jogjakarta is already hot today. No more hotels, as this city needs infiltration areas"*.

According to quotes #60 and #61, environmental impacts that were considered become the main orientation used by student S6 and S27 whom the before-instruction answer was integrated pattern. This perspective supports the answer to be recognised as rationalistic and this indicates, therefore, that students' reasoning changed after the SSI-lesson.

## 6.3 Discussion

This chapter focuses on the pattern of students' informal reasoning skills regarding socio-scientific issues (SSIs)-based instruction that was implemented with every group of students who participated in this research. On the basis of before and after participating in the SSIs-learning test, the patterns of student informal reasoning related to the issue are revealed and discussed.

### *6.3.2 The role of perspectives or orientations on students' informal reasoning*

A key point that was represented from a distinct patterns of pre-instruction students' informal reasoning generated by students is that every individual student potentially had prior capability to make a resolution for each particular SSI. In line with Zeidler and Nichols (2009), this reflects the functionality of SSIs implemented in this study to encourage students to apply their scientific knowledge, as well as moral and ethical considerations to generate decisions toward the SSIs which were discoursed. This role ascertains what Sadler and Zeidler (2005) highlighted in their study that involving personal or social factors, as well as moral and ethical considerations are undeniably carried out by students to make decisions about the socio-scientific issues being learnt. Moreover, they also asserted that the multidimensional reasoning pattern revealed from their research was influenced by the range of perspectives held by students that underpinned the decisions. The basis of perspectives, or orientations, could also be viewed on students' responses either before or after the SSIs lessons in this research.

Although intuitive reasoning does not appear especially on issue #1, it was used by few students in responding to each issue before the SSIs learning. As instances of the intuitive reasoning pattern, quotes #11 & #23 represented various perspectives or orientations held by students. A simple idea on the limitation of mobile phone usage, for example, which was offered by student S9 from SMAN 11 Yogyakarta (quote #11), along with its counterpart expressed by a student from SMAN 1 Kasihan (quote #23), represents the personal-psychological point of view with focus on a possible situation that might be experienced or used. However, these perspectives or orientations were not supported by any premises or other argument components that might reinforce the students' reasoning.

Shaw (1996) asserted that the plausibility of what initial belief or perception that is valued true or relevant, also relates to the difficulty of identification of premises and conclusions as well as to define the link between these elements. This may influence students who are unable to make argument-based decisions and, thus, intuitive reasoning which is simply featured might be generated. In this limitation,

nevertheless, intuitive reasoning may still be meaningful as a SSI resolution. Although intuitive reasoning sometimes originally resulted from a gut-feeling that is immediately expressed, it could naturally be generated to respond to a particular SSI so this reasoning then can be defined as a type of informal reasoning and becomes a significant factor for the resolution of SSIs (Sadler & Zeidler, 2005).

Further review of other students' informal reasoning before SSIs-lessons revealed a distinct feature of expression: a few answers provided in response to each SSI have a different perspective or orientation and were characterised to be more complex than the intuitive pattern described previously. Based on the data of students' informal reasoning of some perspectives or orientations such a concern for stakeholders (i.e., doctor's capacity and political or government policy) (e.g quote #39), economics (e.g quote #1), people's interests and habits (e.g quotes #12, #13), social values and justice as well as empathy to others (e.g quote #24, #25), were the main factors that enabled students to generate their arguments and decisions. Since the decisions were to look at the issue from a social point of view by which a care perspective with empathy and concerns for others' interest and needs are emphasized, the reasoning process carried out is described as emotive reasoning (Sadler & Zeidler, 2005).

Dealing with the complexity of the argument reviewed on the students' answers revealed that besides a decision, there are also argument components to support the decision. Quote #2 is an example which was offered by student S2 regarding the issue of breastfeeding vs formula. A statement like: *"…because there would be some nutrients in the formula milk which are not appropriate with the baby's needs. Therefore, the doctor's note is important to ensure for baby's health"*, illustrates the idea which, according to Shaw (1996), represents the component of premises by which the main claim (i.e., the decision) could be accepted. Other responses like: *"I agree to reduce the effect of EM radiation. Limitation of wifi will lead to lessening of mobile phone use, thus the risk can be limited"* (Quote #26; S18), also represent the feature of premises in the reasoning expressed by students which specify the complexity of students' reasoning in the emotive pattern.

Interrelation between the perspectives or orientations of reasoning and the ability to link the premises and the main claim of an argument may also lead students to generate more complex of reasoning processes in a different pattern. Students' quotes with their specific orientation or perspectives especially about the cause and effect consideration, such as nutrient appropriateness to baby's health, disadvantages and health risk regarding wifi and mobile phone usage, or toward environmental impact (issue #3 and #4), characterise this feature of complexity of students' responses that were made with logical-rationalistic consideration. Therefore, these answers are defined as rationalistic reasoning patterns (Sadler & Zeidler, 2005).

If the above discussed students' informal reasoning relied on the single pattern (i.e intuitive, emotive, or rationalistic), students' informal reasoning which comprised of the combination of single patterns was also revealed. Rationalistic-emotive arguments which place a concern on breast milk excellence associated with emotional relationship between mother and baby that were expressed toward issue #1 (Quotes #4 & #5), or a mixed view about socio-economic interest, the health risk and habit on issue #2 (Quotes #15 & #16), or an interrelated idea which involves social needs, government policy and environmental impact for issue #3 and #4 represent tangible instances of the combination feature of reasoning which, according to Sadler and Zeidler (2005), can be defined as the integrated reasoning pattern. Furthermore, it should be noted that since integrated reasoning involves two (or more) singular reasoning patterns where the patterns could either coordinate or conflict with each other, the argument derived from the integrated reasoning pattern may look more complex than others.

These findings affirm the role of the individual's orientation or perspectives as the basis of reasoning by which students could be able to make decisions toward the socio-scientific issue discoursed. It is suggested that students who tend to apply a personal-psychological perspective might generate their reasoning in the intuitive pattern. For those who place a concern on social values and consideration tend to apply the emotive reasoning pattern, and those who are able to view the logical-

rationalistic aspects will use the rationalistic pattern. Therefore, the wider perspectives held by students and the more capable they in determining the link between premises and claims (or decisions) will imply that they can apply the sophisticated multidimensionality of the decisions (Sadler, 2004; Wu, 2013; Wu & Tsai, 2007; Yang & Anderson, 2003).

Highlighting the important role of perspectives or orientations on decision making regarding SSIs is supported by previous research which showed various backgrounds that underpinned students' reasoning on SSIs and the modes of reasoning (e.g Patronis, Potari, & Spiliotopoulou, 1999; Wu & Tsai, 2007; Yang & Anderson, 2003). However, instead of categorising recognised or simplified students' arguments into modes of reasoning as in previous studies, this research tended to view each perspective or orientation of students' answers to insightfully understand students' decision preferences. Furthermore, the emergence of a distinct reasoning perspectives or orientations revealed in this research reflects the functionality of SSIs-lessons to allow students to expose multiple perspectives, -either psychologically, emotionally or scientifically -, and hold a certain position about the issue (Lee et al., 2013; Zeidler & Nichols, 2009).

### *6.3.3 Trends in the changes of informal reasoning patterns*

The trends in the changes of students' informal reasoning patterns could be highlighted based on each issue as follows:

1) Regarding issue #1-Breastfeeding vs formula, it could be pointed out that: 1) a few emotive arguments that were expressed by students before the implementation of SSIs further changed to be the rationalistic, 2) rationalistic reasoning arguments that mostly occurred tend to remain the same and become even more evident with additional factors of orientations (i.e., the aspect of risk), and 3) for students who were more likely to stand on a single reasoning pattern after participating in the SSIs-lesson rather than on the integrated pattern like they did before a SSIs-lesson.

2) Informal reasoning statements on the issue #2-Mobile phone and society that were provided by two groups of students from SMAN 11 Yogyakarta and SMAN 1 Kasihan, Bantul, also showed a specific trend in the change of informal arguments. *First*, although expressing the same pattern after SSIs-implementation, intuitive argument which was expressed by student S9 from SMAN 11 Yogyakarta showed a different decision toward the issue since the student had a different orientation (see quote #11 & quote #17). This was unlike its counterpart expressed by student S6 from SMAN 1 Kasihan, Bantul which was the same decision (see quote #53 and #54). *Second*, of the emotive arguments that were mostly changed into a rationalistic pattern were those from students of SMAN 1 Kasihan, Bantul. *Third*, similar to the previous issue (Breastfeeding vs formula), students who initially had integrated reasoning patterns before the SSIs-learning then provided a different pattern after the lesson which became a single pattern (either emotive or rationalistic).
3) For issue #3-Motor cycle driven by students, it was shown that whilst those who had emotive arguments tend to keep their reasoning pattern after the SSIs-lesson, students who initially had intuitive argument before participating in the SSIs-learning changed their reasoning to emotive ones after instruction. Similar to the former unchanged-emotive reasoning, mostly rationalistic reasoning that was expressed by students before the SSIs-learning also persisted after the instruction. On the other hand, some integrated arguments which occurred before the SSIs-lesson further changed into single patterns that were mostly emotive.
4) One interesting evidence could be pointed out from students' informal reasoning on issue #4-Hotel development & water sustainability, is that intuitive arguments which initially occurred before the SSIs-learning were changed into rationalistic patterns after instruction. Moreover, both students' emotive and rationalistic arguments remained after instruction. Lastly, like other arguments on previous issues, the integrated reasoning pattern that was expressed before the SSIs-lesson tended to change mostly into rationalistic ones.

The data showed the extent to which informal reasoning patterns that were initially expressed by students before participating in SSIs-lessons could be shifted to other pattern(s). These changes reflect the possibility of the adaptation of the argument perspectives or orientations during the SSIs-lesson and may contribute to students' thought for further decisions after the instruction. The adaptation reflected a meaning of student learning experiences which through SSIs-lessons the students were encouraged to consolidate and elaborate their existing ideas (Venville & Dawson, 2010). Moreover, the SSIs-based learning allows students to experience a learning process of argumentation and achieve more understanding about SSIs that will empower students' decision making skills in the classroom (Sadler, 2004, 2009; Zohar & Nemet, 2002). Dealing with the adaptation as well as the role of perspectives or orientations that previously described, the way of the SSIs-based learning that potentially promotes a reasoning empowerment may be viewed from the lens of the informal reasoning-related theories which were previously established and used in other studies (i.e Shaw, 1996; Wu & Tsai, 2007).

The first theory is the mental model theory which is characterised as "the structure of the model corresponds to the structure of the situation that is represents" (Shaw, 1996, p.54). According to the theory, an initial phase of evaluating arguments for making a decision toward an issue is that students usually use their general knowledge to imagine a situation in which the premises and conclusions of an argument might be true as well as compatible in resolving the issue. It could be suggested that the term 'situation' reflects a conflict or dilemma which students are facing that correspond to the SSI being discussed and challenges students to use their basic knowledge within a distinct perspective. Thus, the initial phase of the mental model is in accordance with the implicit system (or System 1) in the dual process theory (Wu & Tsai, 2007) which is suitable to represent the students' informal reasoning that were expressed before participating the SSIs-lessons.

According to the implicit system, or system 1 of the dual process theory, prior knowledge and personal beliefs that are instantaneously retrieved from long-term memory play an important role to assist students to immediately generate an initial

argument toward the issue. Considering various patterns of informal arguments that were generated by students before participating in the SSIs-lessons, it could be noted that:

1) Besides the issue #1-Breastfeeding vs formula, in which intuitive reasoning did not occur, this pattern of informal reasoning obviously could be counted in other issues. As intuitive informal reasoning is featured as mainly based on immediate feelings or reaction either positively or negatively, and contributes to the eventual resolution of the issue (Sadler & Zeidler, 2005), it is a common tendency that students might initially make an intuitive argument (Wu & Tsai, 2007).
2) Students' arguments which could be defined either as emotive, rationalistic or integrated reasoning reflect various potential backgrounds of science knowledge as well as psycho-social experiences held by students and may support them to make an initial decision toward the issue. However, it should be noticed that perspectives or orientations that underpinned the arguments were more likely to have limited premises or reasons.

The way these initial informal arguments may or may not have changed after participation in the SSIs-lesson could be explained with the explicit system, or system 2 of the dual process theory (Wu & Tsai, 2007). By the system 2, after obtaining additional information, knowledge or emotional experience in the group activities during the SSIs-learning process, the student's prior argument could possibly be revised and a new decision toward the issue might be generated. Carefully reconsidering the perspective or orientations that underpinned students' decisions after participating in the SSIs-learning, suggest that the role of additional information as well as extended knowledge and emotional experience in the change of students' informal reasoning makes sense. As highlighted above, it is evident that the more rationalistic and emotive patterns are preferred as the tendency of a lessening of intuitive pattern expression occurs. Moreover, according to the findings of the students' experiences and perceptions of the SSIs-based learning, it

also shows the valuable meaning of the learning process in which students were involved (see Chapter #5). Similar findings in regard to the change of the students' decision after a SSIs-scenario is also revealed in some research (Lee & Grace, 2010; Wu, 2013; Wu & Tsai, 2007).

The above described interpretation confirms what previous studies have pointed out the impact of the discussion activity in SSIs-learning (e.g., Venville & Dawson, 2010; Wu & Tsai, 2011; Yang & Anderson, 2003). From the constructivism perspective, it is suggested that besides prior knowledge, epistemological beliefs regarding the way an individual probes and processes important information is an important factor on the decision making process. In the process, an individual firstly will use his/her prior knowledge to generate personally-relevant representations about issues or the outside environment. While this representation is being created, incoming information about the issue or situation will be perceived. By taking into account his/her prior knowledge and perceiving the information, an individual will be adapting his/her views and beliefs to build the revised decision. From the psychological point of view, decision-making involves a process of selecting a range of possibilities in which personal beliefs, values and emotions play a crucial role toward generating the decision that would be appropriate with self-needs. To sum up, this research further affirms the role of SSIs-based learning in engaging students on value commitments, promotes a better understanding of science knowledge, argumentation skills, and encourages the development of informed epistemologies (Sadler & Zeidler, 2005).

# CHAPTER 7
# TEACHERS' PERCEPTIONS OF SSIs-BASED TEACHING

## 7.1 Overview

Dealing with research question #4, this chapter presents the data and discussion about biology teachers' experiences and perceptions of SSIs-based teaching that they implemented in this research. The research question is: *"What are Indonesian biology teachers' perceptions of SSIs teaching practice?"*.

Based on the research method described in Chapter #3, particularly in the context and research framework section which comprised four phases of research, three methods of data gathering were mainly used, including written journals, interviews and class observations. Thus, the analysis of teachers' perceptions in this part of the thesis will be mainly qualitative.

The data analysis framework used in this chapter is modified from the existing literature (e.g. Lee, Abd-El-Khalick & Choi, 2006). The literature mentions three importance dimension of teachers' perceptions, including the necessity of including SSI (in science instruction), situational factors related to addressing SSI in class, and teacher's epistemic belief regarding SSI. However, as this research considers the importance of teacher knowledge of SSI and scientific literacy for the SSI-teaching practice, this dimension is taken into account in the framework. Thus, four dimensions of teachers' perceptions are used as the propositions for the general strategy of the analysis, including: 1) teachers' knowledge of SSIs and scientific literacy, 2) the necessity of SSIs in the biology classroom, 3) factors influencing SSIs-teaching and learning, and 4) teacher beliefs. For each dimension, teachers' perceptions will be described and explained through a cross-case analysis approach based on the *variable-oriented* strategy (see Chapter #3 in cross-case analysis section). The data that are used in this chapter had been previously reviewed and

confirmed by the teacher-participants based on the member checking approach as the quality standard of this research.

## 7.2 Data of Teachers' Perceptions of SSIs-teaching Practice

Underlying the four key dimensions of perceptions as presented above: (1) teachers' knowledge of SSIs and scientific literacy, (2) the necessity of SSIs in the biology classroom, (3) factors that influence SSIs-teaching and learning, and (4) teacher beliefs, data of teachers' perception of SSI-teaching practice are described on the basis of before and after the implementation of SSI-teaching for each dimension of perceptions. Mostly from interview, data of teachers' perceptions of SSI-teaching practice are represented and discussed in the following sections.

### *7.2.1 Teachers' knowledge of SSIs and scientific literacy*

Based on the prior reflections through interview, it is indicated that teachers may have a distinct prior knowledge about SSI as well as scientific literacy. The following excerpts from two teacher's perceptions towards and experiences of SSIs and scientific literacy teaching support this finding:

**Interview #1**

| | | |
|---|---|---|
| *Researcher* | : | *"So far, based on your experience, what do you know about SSI?"* |
| *Ms. Aisi* | : | *"[What I can say about SSI is] it is a conceptual web of biological knowledge, and involves social perspectives"* |
| *Researcher* | : | *"Can you please tell me more about those – a conceptual web and social perspectives?"* |
| *Ms. Aisi* | : | *"Upon a SSI, about breastfeed and formula, for instance, there might be a various opinions expressed by people toward the issue. It is necessary to have a proper related-knowledge as well as communication skill to deal with the issue."* |
| *Researcher* | : | *"What about the conceptual web as you mentioned before?"* |

| | | |
|---|---|---|
| *Ms. Aisi* | : | *"[What I am thinking was] it should not only one biological concepts that we need to consider in dealing with SSI, but could be some that are related to the issue. That is what I meant [with a conceptual web]."* |
| *Researcher* | : | *"And what about scientific literacy? What do you think about it related to SSI?"* |
| *Ms. Aisi* | : | *"Scientific literacy means having a knowledge related to, be able to find information, and communicate these to resolve a SSI"* |
| *Researcher* | : | *"What is need to be communicated to?"* |
| *Ms. Aisi* | : | *"Information or facts that are relevant to the issue, and also relevant to biological concepts"* |

Based on the excerpts, it could be argued that the teacher has her own prior understanding about SSI and scientific literacy. According to Ms. Aisi's words, she viewed biological knowledge and social perspectives as two main aspects of SSI. She also added that the related knowledge which may be functional to deal with the issue is supposed to be more complex instead of only a simple concept. Regarding scientific literacy meaning, the teacher stated three main abilities that comprise the scientific literacy skill, including having an appropriate knowledge, seeking relevant information, and communicate a proper understanding to resolve the issue. This might not be much different to other teacher, like Mr. Budi's stated as follows:

**Interview #2**

| | | |
|---|---|---|
| *Researcher* | : | *"So far, do you think you are interested to implement SSi in your class?"* |
| *Mr. Budi* | : | *"I think yes, I am interested. Based on some model of instruction that I already know, this [SSI] is something new for me. I see it potentially be able to motivate student to learn biology comprehensively, not textually"* |
| *Researcher* | : | *"What you can tell me about SSI? What do you know about that?"* |
| *Mr. Budi* | : | *"Mhh…, seems I can figure it out briefly. Perhaps, if I can get an idea about the issue, I think my understanding will be enhanced"* |

| | | |
|---|---|---|
| *Researcher* | : | *"Can you tell me more?"* |
| *Mr. Budi* | : | *"Like I wrote in my [reflection] sheet, SSI is a problem in society and related to science or biology"* |
| *Researcher* | : | *"Oh, you meant your experience when teaching about food preservative?"* |
| *Mr. Budi* | : | *"Yes"* |
| *Researcher* | : | *"So you thought it represents SSI?"* |
| *Mr. Budi* | : | *"I hope so"* |
| *Researcher* | : | *"And what do you know about scientific literacy?"* |
| *Mr. Budi* | : | *"It [scientific literacy] is a way to learn science. That what I know so far"* |

One could point out that, according to Mr. Budi's statement (e.g., this something new for me), SSI is a new knowledge for him and this may influence his prior understanding about it. Mr. Budi described SSI as an issue that exists in society and interrelated to science (biological) knowledge, which compared to Ms. Aisi's earlier statement, seems simpler and less elaborated. Regarding scientific literacy, he means it as a way that may lead students to learn science (biology).

According to the above-described perceptions expressed by two teachers, it could be suggested that a lack of experience on SSI-based instruction considerably influences teachers to figure out their understanding about SSI as well as scientific literacy based on their prior understanding. This lack of experience is explicitly stated by Mr. Budi. On the other hand, in the case of Ms. Aisi, since she is a fresh graduate of biology teacher program and has a lack of experience in biology classroom, it is likely complicated for her to describe those two essential concepts. However, their experience in SSI-based instruction teaching practice is likely lead them to have a different view about SSI as well as scientific literacy.

Based on interviews after the implementation of SSIs-teaching, the following excerpts are their answer regarding the question: *"We had tried to implement SSIs-based teaching [with a selected issue]. Do you think it was representing a SSI?"*, and *"So, how is your understanding about scientific literacy?"*

**Interview #3 - Mr. Budi:**

*"I think it was. As there was a controversy between biological knowledge and social aspects related to breastfeeding and formula milk. This leads students to make a decision [about it]"* (Interview #3; excerpt #1)

*"What I can see yesterday is students reviewed a number of information relevant to the issue in different perspectives in order to make a decision toward the issue and deliver their reasoning to the class. I think this is scientific literacy."* (Interview #3; excerpt #2)

**Interview #4 - Ms. Aisi:**

*"What I can say about SSI, and also scientific literacy, is these are more complex than I previously thought. A main point of SSI is a controversy between science and social dimension."* (Interview #4; excerpt #1)

*"Scientific literacy is a skill necessary to deal with SSI"* (Interview #4; excerpt #2)

Reviewing the views after-SSI teaching practice stated by both teachers, Mr. Budi and Ms. Aisi revealed a trend of change on their perceptions of SSI and scientific literacy. Both Mr. Budi and Ms. Aisi had likely found a key point on SSI knowledge as they mentioned "a controversy between science and social dimension". However, Mr. Budi had an additional understanding as he asserted decision-making aspect in his statement on SSI. Regarding scientific literacy understanding, there is also a distinct thought between both teachers. Whilst Ms. Aisi simply stated scientific literacy as *a skill necessary to deal with SSI*, Mr. Budi involved selecting relevant information, decision, and reasoning in his meaning toward scientific literacy. In sum, in different degree, there is an extent to which additional knowledge about SSI as well as scientific literacy are gained by teachers after SSI-teaching practice.

### *7.2.2 The dimension of the necessity of SSIs in the biology classroom*

According to interview findings before SSI-teaching implementation, teachers perceived the necessity of SSI-lesson from the point of view of its educational advantages, as represented by the following excerpts:

**Interview #5**

| | | |
|---|---|---|
| *Researcher* | : | *"You mentioned before that you are interesting to implement SSI in your biology classroom. What makes you interested?* |
| *Mrs. Dwi* | : | *"Well, based on my limited knowledge on SSI that we discussed before, I think it [SSI] will help my students to understand the biological concepts as well as arise their empathy or humanistic values. It may also helpful to regenerate students' awareness on their environment as it is likely lessen currently. Through SSI, perhaps my student could review social values in their daily life"* |
| *Researcher* | : | *"Did you see a possibility of SSI implementation in your biology class?"* |
| *Mrs. Dwi* | : | *"I believe it [SSI] could be implemented"* |
| *Researcher* | : | *"What may support your thought? Did you see a potency of the context, maybe?"* |
| *Mrs. Dwi* | : | *"I consider my students are tend to up to date their lifestyle, socially, I meant. Using contact lens, for example. But, seems that they are aware about the risk. I suggest, learning through SSI may help them to more aware, realize, know what they really need, have the reason using it"* |

**Interview #6**

| | | |
|---|---|---|
| *Researcher* | : | *"Do you think SSI is different with other instructional strategy?* |
| *Ms. Aisi* | : | *"Yes, I think so"* |
| *Researcher* | : | *"Why?"* |
| *Ms. Aisi* | : | *"I think SSI may accommodate students to be more encourage to get knowledge"* |
| *Researcher* | : | *"Only biological knowledge?"* |
| *Ms. Aisi* | : | *"No, it also may help students to have social consideration, besides understanding the biology topic being discussed"* |

Although it was not explicitly stated as the necessity of SSI-lesson, the teachers' words in the above excerpts considerably reflected the way they viewed the importance of SSI for their biology classroom. From Mrs. Dwi's statements in interview #5, for example, she asserted the potential role of SSI to help her students have biology knowledge as well as the social considerations related to the issue, and also be aware of their reason. Dimension of knowledge and social consideration also emerged in Ms. Aisi's words to support her view on the advantage of SSI lesson.

Reviewing teachers' reflection after SSI-teaching practice shows their perceptions which looked more profound regarding the advantages of the SSIs-based learning, particularly in terms of an increased level of engagement from their students. These were reflected by the excerpts below:

**Interview #7**

| | | |
|---|---|---|
| *Researcher* | : | *"So, how can you share your experience to me regarding the function of SSI-lesson for your biology classroom?* |
| *Ms. Aisi* | : | *"Well, the first thing I can see from my class is students looked more engaged in SSI-learning, and this is supported by some students whose I asked their opinion about their lesson"* |
| *Researcher* | : | *"How did you see your students were more engaged?* |
| *Ms. Aisi* | : | *"When they did group observation, the way they were seeking and sharing the information"* |
| *Researcher* | : | *"Was there something special?"* |
| *Ms. Aisi* | : | *"They said it was their first experience in having such role-play discussion with SSI. They perceived it was different"* |
| *Researcher* | : | *"Mostly about group activity?"* |
| *Ms. Aisi* | : | *"I can see some students were trying to do critical thinking, especially when involve in group discussion."* |

**Interview #8**

| | | |
|---|---|---|
| *Researcher* | : | *"So, did you see something interesting about SSI-learning in your biology classroom?* |

| | | |
|---|---|---|
| *Mrs. Dwi* | : | *"I see my students were looked more attracted. Seems it because they felt free, different with their common learning pattern"* |
| *Researcher* | : | *"Do you think it relates to the context?"* |
| *Mrs. Dwi* | : | *"I think so, and maybe they feel bored to my teaching way as well"* |
| *Researcher* | : | *"What about student achievements?"* |
| *Mrs. Dwi* | : | *"Students are looked really encourage to express their social consideration and responsibility, like "L" [a name of student] who wanted to participate in community service for campaign the issue. Overall, I consider my students become more aware about social dimension upon the topic being learnt"* |

According to the above excerpts, the teachers perceived few key aspects of SSI-lesson advantages in relation to the student activities. One of them as asserted by Ms. Aisi was the encouragement from the group activities where the students critically shared information and opinion. Similarly, Mrs. Dwi also focused at her student engagement in SSI-lesson. She noticed that in SSI-learning, her students were *"… become more aware about social dimension upon the topic being learnt"*. Therefore, compared to their words before the implementation of SSI-teaching (interview #5 & #6), this after-SSI teaching practice reflection shows an extent to which the teachers gained a wider point of view to consider SSI-learning advantages, or necessity, for their biology classrooms.

### *7.2.3 The dimension of factors influence SSIs-teaching*

According to the findings, all teachers stated that defining the issue which evolved in society as well as having relevance to the biology topic, and also exploring relevant scientific information about the issue, were viewed as two main factors that needed to be considered. Following these topic-related factors, teachers became aware about pedagogical aspects as important factors, including an appropriate teaching approach or model (Mr. Budi and Mrs. Dwi), student characteristics (Mrs. Dwi and Mrs. Nur), and teacher skills and creativity (Ms. Aisi and Mrs. Dwi). The words expressed by Mrs. Dwi below represent the findings:

**Interview #9**

| | | |
|---|---|---|
| *Researcher* | : | *"So, do you think you are interested in teaching with SSI?"* |
| *Mrs. Dwi* | : | *"I am interested, but honestly, not really ready"* |
| *Researcher* | : | *"Why"* |
| *Mrs. Dwi* | : | *"As I am not fully understand, or have no clear idea on how to teach with SSI. I think I need more reference about theoretical and practical guide in SSI-teaching. I also concern on how fit SSI to our curriculum need."* |
| *Researcher* | : | *"What about other factor that related to, for example, teaching preparation?"* |
| *Mrs. Dwi* | : | *"Perhaps the learning resources. I do not know how appropriate it is, but usually I allow my students to find through the internet"* |

Having an experience in SSIs-teaching practice may lead the teachers to take into account the factors more deeply. Another perspective occurred from Mrs. Dwi's experience, as she explained:

**Interview #10**

| | | |
|---|---|---|
| *Researcher* | : | *"Do you think SSIs-teaching that you have implemented is in alignment with our curriculum needs?"* |
| *Mrs. Dwi* | : | *"To some extent. But, as you know, our curriculum is mainly oriented toward national exams, and the teacher must teach all topics or concepts required. To be honest, I am actually interested in SSIs-teaching, as it is relevant to the science-technology-society approach. But, we have limited time as we have to consider the final exam"* |
| *Researcher* | : | *"What is your regular teaching pattern?"* |
| *Mrs. Dwi* | : | *"It depends on the topic. However, according to my colleagues here in the school, a teacher could not be called a teacher unless she/he is able to teach by lecturing"* |
| *Researcher* | : | *"Does [it mean that] this teaching culture [lecturing] influences the way students learn?"* |
| *Mrs. Dwi* | : | *"Definitely. The teacher is delivering the concepts and perhaps the student receives the knowledge. They [students] are accustomed to this pattern. They have a book, but if they are not* |

*be encouraged to read, they will not to do that. They prefer to be taught by lecturing"*

It is revealed by Mrs. Dwi's words that the teacher is facing a dilemma as, on the one hand, she is actually encouraged to teach about SSI, but on the other hand, she is also aware of the demands of the final examination. This may become more challenging because there is an extent to which teaching culture in her school influences her perceptions of the way she needs to choose to teach her biology classes. Thus, this school orientation and culture represent factors that may also influence SSIs-teaching practice.

### *7.2.4 The dimension of teacher belief*

According to personal communications with each teacher, it was generally revealed that there is a psychological dilemma faced by the teachers to decide whether they intend to implement SSI-teaching. Mr. Budi's and Mrs. Nur's statements below may represent this finding.

**Interview #11**

*Researcher* : *"After participating in the workshop, do you think you are interested about SSIs?"*

*Mr. Budi* : *"I am interested. Based on some models of instruction that I already know, this [SSIs] is something new for me. I see that it could motivate students to learn comprehensively, not textually"*

*Researcher* : *"What do you need to do for preparing in SSIs-based instruction?"*

*Mr. Budi* : *"I strongly need a guide, an example of SSIs-teaching materials and a real example on how to implement SSIs-based instruction"*

*Researcher* : *What challenge(s) do you think will occur?*

*Mr. Budi* : *"Students' heterogeneity and my teaching habit which is teacher-centred. With the SSIs-model, it would be challenging how to encourage students to adopt thinking skills more toward the issue being discussed. Whereas, the most common duty in*

*my teaching is explaining [the topic], giving questions, and possibly, providing a hands-on activity about the topic. In other words, the most important problem that ordinarily emerged is how to change, or innovate teaching and learning ways in the class to be more student-centred"*

**Interview #12**

| | | |
|---|---|---|
| *Researcher* | : | *"How do you understand SSIs?"* |
| *Mrs. Nur* | : | *"I had heard it [SSIs] before. But since we teach biology as curriculum oriented, we just follow what the curriculum intends. To date, I never learnt more"* |
| *Researcher* | : | *"In your view, what does SSIs-teaching look like?"* |
| *Mrs. Nur* | : | *"We view an issue in our life, environment, up-to-date in our society. However, if a teacher wants to teach such an issue, the teacher needs to understand it first and its relation to relevant biological concepts"* |
| *Researcher* | : | *"Do think you are interested to do it [SSI-teaching] in your biology class?"* |
| *Mrs. Nur* | : | *"Well, it is interesting, actually. But, at this time, I am not so sure if I can"* |
| *Researcher* | : | *"Why?"* |
| *Mrs. Nur* | : | *"The fact that I have no experience on it, as well as appropriate knowledge. But, I interest"* |
| *Researcher* | : | *"The main point is, you are interested, right?"* |
| *Mrs. Nur* | : | *"Mhh.., yeah"* |

According to the above excerpts, there is likely a mental conflict that challenges the teachers regarding their belief to SSI-teaching practice. On one hand, a lack of experience as well as knowledge on SSI-lesson made them unsure if they are ready to take a role in SSI-teaching. However, after looking at the potential advantages of SSI-instruction perceived after the workshop, on the other hand, made them more interested in doing SSI-teaching.

Experiencing SSI-teaching may lead to a different degree of the change of teacher belief regarding SSI-teaching practice. For Mr. Budi, for example, the change is

reflected by the idea of potential biological topics that can be further considered, as he described in the following excerpt:

| | | |
|---|---|---|
| *Researcher* | : | *"After practicing SSI-teaching, do you think what the difficulties that you face are?"* |
| *Mr. Budi* | : | *"How to ensure that the context of the issue conforms with the topic in the syllabus, or our curriculum, and its relevance to social values. It could be hard to do"* |
| *Researcher* | : | *"And what about the challenges or threats?"* |
| *Mr. Budi* | : | *"Generally, if students have a good feeling, the lesson plan could be implemented properly. Otherwise, it would be a challenge if we find students who tend to be inactive, so that we need to give extra attention, and, unfortunately, it could be an inappropriate use of time."* |
| *Researcher* | : | *"But, do you think it is possible for further implementation?"* |
| *Mr. Budi* | : | *"Very possible. For instance, in grade 10, it is possible for the topic of vaccination, or the immune system in grade 11. For grade 12, eugenics or evolution are potential topics."* |
| *Researcher* | : | *"Will you do, next?"* |
| *Mr. Budi* | : | *"I think so"* |

According to his words, Mr. Budi accentuated that convincing a conformity of the context of SSI to biology curriculum need as a difficulty on SSI-teaching implementation. On the other hand, it seems that he was ready to deal with it when he could find a particular biology topic which can potentially be applied in SSI-instruction. Moreover, instead of seeing any challenge or threat from himself, Mr. Budi is aware of his students' motivation that might be an important factor for the effectivity of SSI-learning. However, in his last words, it is reflected that he has a motivation and he looks forward to do SSI-teaching again.

Compared to Mr. Budi, a similar view was represented in Ms. Nur's words, as she stated below:

| | | |
|---|---|---|
| *Researcher* | : | *"Well, how do you think about SSI-teaching after the implementation?"* |
| *Mrs. Nur* | : | *"SSI-lesson requires more time in implementation than the conventional way like I mostly do. If it will be implemented, it is a strong need of teacher creativity on designing lesson plan, and teacher has to mastery the issue as well as biological knowledge"* |
| *Researcher* | : | *"Particularly for teaching materials, what is need to be considered?"* |
| *Mrs. Nur* | : | *"Looking for an up-to-date information and complying news, so that teacher has a deep understanding about SSI that will be implemented"* |
| *Researcher* | : | *"Do you think you will try to implement SSI-teaching again, next?"* |
| *Mrs. Nur* | : | *"I hope so"* |
| *Researcher* | : | *"What does it mean?"* |
| *Mrs. Nur* | : | *"SSI is interesting, as I can see it could make students more attractive, and experience something different. Either their knowledge might also be better. However, I have to make sure myself that I am really ready with appropriate source and valid information"* |

Considering her readiness in implementing SSI-teaching, Mrs. Nur looked really aware of some aspects that might challenge her role in SSI-instruction. Creativity on lesson preparation, mastery the context of the issue as well as relevant biology knowledge, and a well prepared teaching material, are aspects that she considered and took into account of her willingness to do SSI-teaching.

Reviewing teachers' views on their beliefs regarding SSI-teaching practice before and after implementation of SSI-instruction reveals that experiencing a real SSI-teaching practice leads the teachers to acknowledge any challenges as well as advantages in SSI-instruction. Thus, this acknowledgement may grow their self-capacity as well as beliefs in taking a role in SSI-teaching.

### *7.2.5 Patterns of teacher professional growth regarding SSIs-teaching practice*

In order to get an insightful understanding about teacher professional change on SSIs-teaching practice, the teachers' experience as well as their perceptions data were further analysed based on the IMTPG model framework as the basis of individual participants and are represented as pictorial representations. Using the representations, the pattern of teacher professional growth regarding SSIs-teaching practice could be reviewed based on the relationship established between the four domains of the IMTPG model related to five aspects of the SSIs-based teaching by which change sequence or group network modes occur. With reference to the first research question, the chronological view of analysis was also used in an attempt to obtain insight into the difference of the patterns that might emerge both before and after SSIs-teaching practice by each participant. The classifications of the pattern of teacher professional growth on SSIs-teaching are presented in Table 7.1, where T1 refers to Mr. Budi, T2: Mrs. Dwi, T3: Mrs. Nur, and T4 refers to Ms. Aisi.

Table 7.1. The pattern of teacher professional growth on SSIs-teaching before and after the SSI-teaching practice

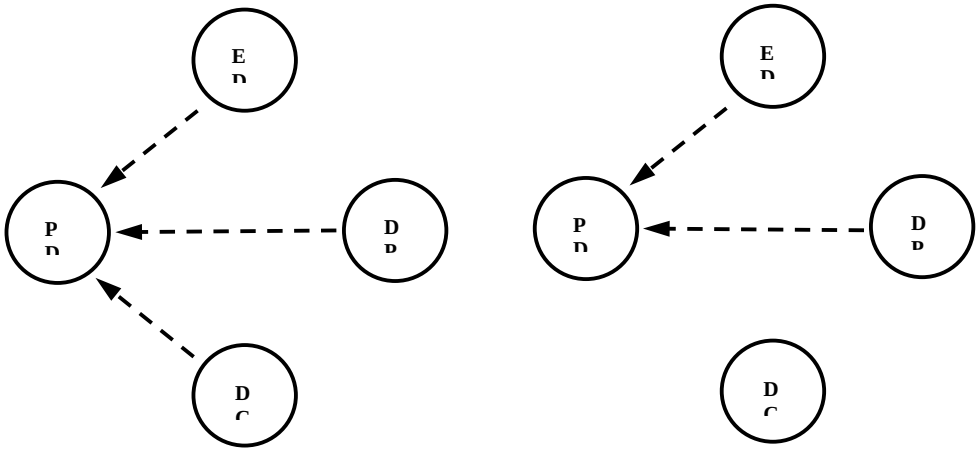
| **Aspects of SSIs-teaching** | **Pre-implementation** | | | | **Post-implementation** | | | |
|---|---|---|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** | **T1** | **T2** | **T3** | **T4** |
| Teacher attribute | [GN] | [CS] | [CS] | [CS] | [CS] | [CS] | [CS] | [CS] |
| Design elements | [CS] | [CS] | [CS] | [CS] | [GN] | [CS] | [CS] | [CS] |
| Learner experiences | [CS] | [GN] | [CS] | [CS] | [CS] | [CS] | [CS] | [CS] |
| Classroom environment | [CS] | [CS] | [CS] | [CS] | [GN] | [CS] | [CS] | [CS] |
| Peripheral influences | [CS] | [CS] | [CS] | [CS] | [GN] | [GN] | [CS] | [CS] |

CS: Change Sequence; GN: Group Network

Table 7.1 shows the extent to which the change of the patterns takes place for each teacher during their participation in the professional learning. Reviewing the pattern will lead to an understanding on how each teacher interpreted his/her experience in SSI-teaching professional development especially regarding the factors that might

influence their perceptions. However, it should be noted that this research does not look at whether or not the change which occurred could be assigned in a positive or negative manner. Otherwise, characterising the change could lead to a review of aspects of the SSI-teaching that may contribute to teacher professional learning. For example, related to the aspect of teacher attributes, Mr. Budi (T1) and Ms. Aisi (T4) perceived different views about their knowledge and beliefs.

Before implementing the SSIs-teaching, it was found that T1-teacher's knowledge and beliefs toward SSIs-teaching (i.e., the aspect of teacher attribute that connects to the personal domain, PD) were influenced by what he had learned in the workshop which, according to the IMTPG model, could be defined as the external domain (ED). Moreover, two other domains that reflected the aspect are domain of practice (DP) regarding his regular teaching pattern, and domain of consequence (DC) related to the competence that might be achieved by students. This relationship was characterised as group network (GN) pattern because it formed more than two relationships between the domains involved, as illustrated by Figure. 3(a). Within the same aspect, it is shown by Figure 3(b) that T1's knowledge and beliefs after the implementation of SSIs-teaching were driven by the reflections toward two domains, ED and DP. His comment toward SSIs representation reflected the ED, whilst his experience during the practice of SSIs-teaching reflected the DP. Thus, as it depicted two relationships the pattern of teacher's knowledge and belief growth after SSIs-teaching implementation is characterised as the change sequence (CS) mode.




(a) (b)

Figure 3. The development of T1's knowledge and beliefs on SSIs-teaching practice before (a) and after (b) class implementation.

Unlike T1, the distinction of T4's attribute characteristics between before and after is shown by Figure. 4. Depicted in similar mode as the change sequence, the domain that influenced the growth of T4's knowledge and beliefs on SSIs-teaching practice was different. Before the practice of SSIs-teaching, it is shown that her personal domain PD (i.e., knowledge and beliefs) was reflected in the external domain (ED) and the domain of practice (DP). Inadequacy of the biological knowledge understanding that was obtained from previous teacher learning programs and the lack of experience and skills on teaching practice are factors reflected toward each ED and PD. For post implementation of SSIs-teaching, the domain of practice (DP) still occurred as the way the teacher carried out the SSIs-teaching as criticized by students since it was unlike the common pattern experienced by students. Related to this domain, it was also found that student interest in the SSIs-learning environment managed by T4 contributed to the teacher attributes. This student interest, thus, can be viewed as a part of the domain of consequence (DC).

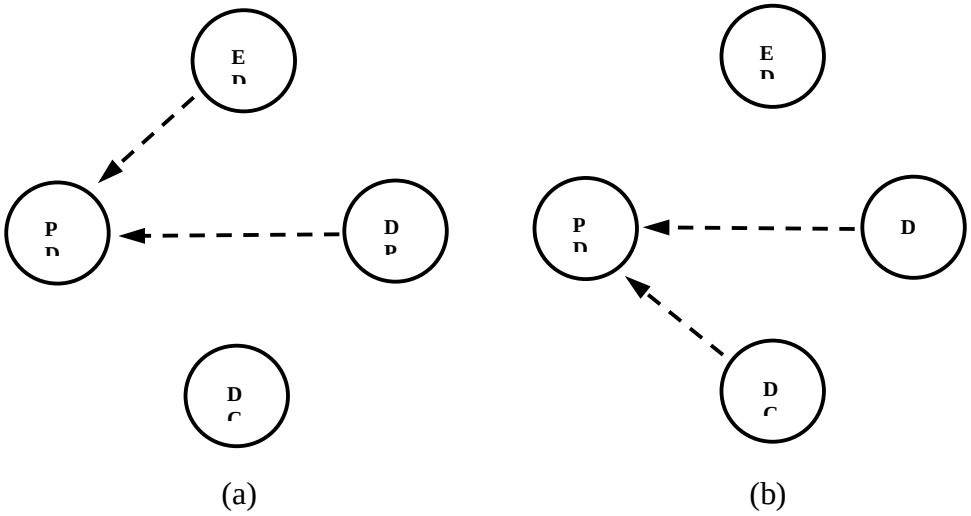



Figure 4. The development of T4's knowledge and belief on SSIs-teaching practice: (a) before, and (b) after SSIs-teaching implementation.

## 7.3 Discussion

The first key finding that was revealed in this research is the fact that before teachers attended the workshop, SSIs-based teaching was viewed as a new experience by the participants. Their recognition thus explicitly showed that because they had never learnt about SSIs before, they lacked the knowledge about SSIs and scientific literacy orientation in their biology classroom. At this point, teaching experience is likely not related to the state of knowledge about SSI as expressed either by Mr. Budi or Ms. Aisi.

In the case of Mr. Budi who had tried to provide a contextualized problem on the basis of community to his biology classroom, for instance, he did not consider whether the topic he provided for their classes represented SSI. By asking his students to make an observation on meals traded in the community and possible food preservatives used, Mr. Budi intended to attract his students to be involved in the main discourse about the physiology of the digestive system. However, it is viewed that the idea which underpinned his instruction was limited in an attempt to engage students in the topic. On the other hand, there is a confusion expressed by Ms. Aisi to define the appropriate meaning of SSI.

Following the evidence of the lack of knowledge about SSIs and scientific literacy-oriented teaching led to another experience regarding learning environment as well as the way of teaching which was habitually implemented by the participants. This circumstance may not be separated from how teachers perceive, interpret and actualize the biology curriculum in classroom instruction, as Mrs. Dwi (excerpt 10) and Mrs. Nur (excerpt 12) reflected on the situation in which the teacher was facing a great challenge on the content-oriented curriculum for ensuring student achievement in their teaching practice. This situation implies to other factors, such as time required for biology instruction and working environment. Therefore, teachers' perceptions of the curriculum orientation of the syllabus when translated into teaching duties as well as into socio-cultural aspects of the school, may have a great influence on their awareness of innovation (Davis, 2003; Konings, Brand-Gruwel, & van Merrienboer, 2007; Pinto, 2005).

The circumstances regarding teacher knowledge of SSIs, the teaching culture and the curriculum orientation seem to have been modified after the workshop activities (Phase 2 of the research) as well as the implementation of SSIs-teaching (Phase 3). Introducing the SSIs-based teaching through a workshop in which participants were involved in discussions about SSIs' conceptualisation and its practical attributes, may provide an occasion for participants to take into account the potential of the SSIs in their biology classroom. Based on the research findings, teachers' perceptions of the necessity of SSIs in biology instruction and factors influencing SSIs-teaching practice represent the basic insights into these dimensions; such insights were expressed by Mrs. Dwi and Ms. Aisi's statements.

In the pre-implementation, participants perceived the dimension of the necessity of SSIs in general points particularly in regard to the learning outcomes which are potentially achieved by students, such as obtaining biology knowledge and having social consideration related to the issue. After practicing the SSIs-teaching in class, it appears that participants developed a deeper insight of the necessity for, such as, strengthening the understanding of biological concepts, building attitudes within

SSI-group activity, developing critical thinking, and also an appropriate view of the curriculum.

Related to the dimension of factors influencing SSIs-teaching, the alteration of teacher perceptions emerged as two different perspectives. Before implementing SSIs-teaching, it is most likely that teachers perceived the factors from an internal point of view which refers to teacher self-needs, such as how relevant the issue is with the demand of the curriculum, the appropriate teaching approach, or available teacher skills. However, the advantages of the classroom environment and student achievements, time requirement, as well as school community or culture are factors that represent the external points of view which are considered by participants after practicing SSIs-teaching in their biology classroom. Therefore, these practical aspects of SSIs-teaching would not be reflected upon unless teachers have experience with them.

A possible reason that could support these findings is practical experience in the class where the SSIs-based classroom environment was created as Guskey (2002) asserts the relation about the classroom experimentation with professional learning with teacher's beliefs and attitudes. In this way, the teacher was able to look at student activities as well as the class situation. By trying to apply an innovation introduced in the professional learning program, teacher will be able to obtain the real picture of the class environment and evidence of student achievement as well as the advantages for herself/himself that could promote the change of beliefs and attitudes. Like Borko (2004), Bakkenes, Vermunt, and Wubbels (2010) also found that classroom practice where the teacher is able to find a real context for what they teach and reflect on in his/her teaching habit as part of professional development, is a powerful medium for teacher change.

The change of the dimension of knowledge about SSIs, the necessity of SSIs in the biology classroom, and the factors that influence SSIs-teaching may drive the change in the rest of the dimension of perceptions, namely, the teaching beliefs. Likewise, these dimensions of the participants' notions mirror the flow of teacher perspective regarding their beliefs on SSIs-teaching. What can be viewed before

SSIs-teaching practice was that most of the participants saw themselves as not competent for the practice due to the lack of knowledge and experience. Nevertheless, attending the workshop as well as the factors that they encountered during experience in the classroom implementation, led them to increase their interest about the practice, and to recognise the advantages and insights for further implementation. However, as Ms. Aisi stated (see excerpt #16, for example), it is considerably clear that the teachers' beliefs with support of knowledge of SSIs can provide a strong confidence and capability for teachers to address SSIs-based instruction. In this way, they can provide appropriate classroom environments for the intended purposes (Albe et al., 2014 ).

The above interpretation is aligned with the valuable contribution highlighted from research by Henze, van Driel, and Verloop (2009) which showed the different variations in the teachers' learning process regarding the stage of development of their concern. Some teachers, who naturally have sufficient competences either in subject matter and/or teaching methods and also a good self-confidence at the start of a professional learning program, tend to look at student concerns. On the other hand, those teachers who are characterised by insufficient competences at the start of a learning program and need a real example of teaching materials or model, are usually still in the early stages of development that mainly focuses on the self as well as on the concerns of the task. Thus, these various learning processes can also be reflected by patterns of teacher professional growth.

Dealing with the patterns which are described in Table 7.1, it is revealed that each participant developed his/her own perceptions based on the experience during the study. It is clear according to Figures 3 and 4, for instance, that the way the teacher perceived his/her experience on professional teaching and learning of SSIs-teaching is influenced by the degree of reflection that could be carried out by the individual teacher. Hence, a considerable interpretation that emerged based on further analysis of the patterns as well as pictorial representations is that the teacher development on SSIs-teaching were mostly characterised as change sequences either before or

after implementing SSIs-teaching. It is likely that general teaching experience is not necessarily an essential factor to determine the degree of reflection.

However, a less likely occasion in which teachers are able to do a reflection toward their role may possibly be a strong reason why their professional growth on SSI-teaching are mostly characterised as change sequence. This implies on the SSI-teaching aspects which were taken into account where, personally, changes in knowledge and beliefs tended to be reflected easier than changes in the teaching practice (Bakkens et al, 2010). By this point, a critical issue that needs to be more considered for further research is the degree of teachers' concern to their personal values regarding controversial SSI that may imply on their teaching practice (Gray and Bryce, 2006). Yet, although this research has not been able to clearly show how strong teaching experience supporting the teachers doing reflection, as highlighted by Reis and Galvao (2004) and Albe et al (2014), a key finding revealed in this research is that a professional learning framework on SSIs-teaching which is employed in this study can enable teachers to perceive the dimension of SSIs-teaching in various productive ways. Indeed, promoting SSI-based instruction as an innovation in science education would have a stronger meaning if it begins with teacher's awareness on his/her ability, beliefs and roles toward the reform practice.

# CHAPTER 8
# CONCLUSIONS, LIMITATIONS AND IMPLICATIONS

## 8.1 Overview

The main purpose of this research was to promote socio-scientific issues (SSIs)-based instruction in secondary school science in Indonesia. Four research questions were addressed in this study toward the purpose of developing an instrument for assessing students' perceptions of SSIs-based lessons, investigating biology teachers' and students' perceptions of SSIs-based instruction, and investigating students' informal reasoning.

This research was carried out using a case study design in two phases. The first phase was used to address the first research question which is related to the instrument development. The second phase followed to address the other three research questions. Moreover, in phase two, SSIs-based instruction was defined as the "case" of the study, which was designed and implemented through a teacher professional learning program.

The teacher professional learning program comprised four stages of activity, including: 1) reflection of teaching experiences and background knowledge, 2) workshops on SSIs-based teaching, 3) the development and implementation of SSIs-based learning materials in biology classrooms, and 4) reflection of post-implementation. During the program implementation, data from biology teachers' perceptions of SSI-based teaching were collected throughout those stages using reflection sheets, personal journals, observations and interviews. On the other hand, data from students' perceptions were collected within stage #3: the implementation of SSIs-based learning materials using the developed questionnaire, observations, and interviews. Students' informal reasoning was assessed with informal reasoning assignment sheets.

Data from biology teachers' as well as students' perceptions were analysed using basic analytic method followed by cross-case analysis. For the first method of analysis, explanation-building mode was used to explain the investigated phenomena. The cross-case analysis was used to examine the data across the cases and to gain a deeper understanding of the results. In addition, a different approach of analysis was used to categorise students' informal reasoning. Furthermore, based on the data analysis, interpretations were developed for the discussion and written for each research question: Chapter #5 for students' perceptions of SSIs-based learning; Chapter #6 for students' informal reasoning; and Chapter #7 for biology teachers' perceptions of SSIs-teaching. Chapter #4 provided an answer to the research question regarding the development of an instrument for assessing students' perception of SSIs-based learning.

## 8.2 Conclusions

Based on the previous chapters, the following sections are presented to summarize the major findings and discussions for each research question.

### 8.2.1 Research Question 1: Do students' perceptions of SSI-learning scales designed for assessing students' perception of SSI-based learning produce a reliable and valid instrument?

The first objective of this research study was to develop an instrument for assessing students' perceptions of SSI-based lessons. As discussed in Chapter 4, the developed questionnaire comprised four scales, namely: contextualisation of SSI, SSI learning objectives, attitude toward SSI-learning, and student involvement. Based on the principal component analysis of the data gathered from the pilot study, 24 items possessed satisfactory factor loadings and four items were removed because they did not load on one factor. For internal consistency, as indicated by Cronbach alpha coefficient, the scale reliability ranged between 0.75 and 0.87. Therefore, the 24 items of questionnaire make up a comprehensive dimension of

learning environment which could be represented as well as perceived by students in the SSI-based learning.

### 8.2.2 Research Question 2: What are Indonesian students' perceptions of SSI-based learning in biology?

To reveal students' perceptions of SSI-based learning in their biology classrooms, the developed questionnaire produced in Research Question 1 was used and also supported with interviews as well as observations. As described in Chapter 5, the research findings about students' perceptions of SSI-based learning can be summarised as follows.

Students perceived SSI-based learning as a new way of learning in biology that useful for students to find a socially-emphasised contextualisation of their biology lesson. This meaning of contextualisation was related to the daily-life contexts reflected from issues to which students are attracted, are easy to understand and for which they were encouraged to be involved in the lesson. Regarding the SSI-learning environment, students perceived it as a positive atmosphere where three aspects of involvement emerged. These aspects involved: 1) engagement for providing ideas or opinions during the SSI discussion, 2) group-mate social interactions, and 3) an occasion in which students are allowed to confirm various idea during the group discussion. These aspects are related to each other and underpin students' perceptions of their involvement in SSI-learning activities.

Dealing with learning achievements, students perceived four main aspects of learning objectives. These include: responding to the issue from multiple perspectives, generated an insightful view of the issues, related-values of science and technology considerations, and communication skills.

Lastly, regarding the dimension of attitude toward SSI-lesson, it was revealed that students' role in the SSI-group activities, teachers' role in doing SSI-based teaching, and students' preference on SSI-learning strategies, are three main dimensions of attitude which were perceived by students toward their SSIs-lesson.

Although in limited degree it is interesting to find that students' perceptions of SSI-lesson are very likely to reflect the self-regulated learning perspective. Based on few data expressed by students, at least two aspects of the self-regulated learning perspective are represented. These include a view of an ideal way to reach expected SSI learning achievement and a critical view of an appropriate learning environment in biology classroom.

### 8.2.3 Research Question 3: What types of informal reasoning can be performed by students based on SSI-based learning?

According to the analysis framework, the type of students' informal reasoning regarding SSI can be defined either as a single pattern being intuitive, emotive or rationalistic, or as an integrated pattern. As discussed in Chapter 6 (section 6.3.1), a key point that was reflected from the research findings is that for every SSI-lesson, each of intuitive, emotive and rationalistic, as well as integrated pattern of informal reasoning was expressed and represents the multidimensionality of reasoning that can be generated by students in responding to the issue.

This multi-dimensionality of reasoning is considerably influenced by distinct perspectives or orientations which underpinned students' responses. A personal-psychological perspective may lead students to provide intuitive reasoning, whilst a concern on social values or consideration underlies their emotive reasoning expression. Different to these two patterns, students' rationalistic reasoning is typically featured by logical-rationalistic considerations that involve cause and effects as well as disadvantages and health risks. In addition to such a single pattern, students were also able to perform integrated reasoning particularly rationalistic-emotive pattern.

Dealing with the distinct perspectives or orientations underpinned students' reasoning patterns, it is shown that SSIs-based learning in which students were participating in this research have encouraged them to reconsider their reasoning perspectives or orientations. This can be reflected by the changes of reasoning patterns that they expressed in responding the issue after the lesson.

### 8.2.4 Research Question 4: What are Indonesian biology teachers' perceptions of SSI teaching practice?

Dealing with research question #4 that relates to Indonesian biology teachers' perceptions of SSI teaching practice, the research findings as well as discussion highlight some important points. *First,* it is considerably revealed that SSI-based instruction is a new experience for Indonesian biology teachers who participated in this research study. Therefore, teacher-participants perceived a lack of knowledge of SSI-teaching practice and scientific literacy oriented instruction. *Second,* biology teachers' perceptions of curriculum orientation that are represented in their teaching duties as well as into school culture have a great influence on the awareness of the necessity of the implementation of an innovation, especially SSI-based teaching that was implemented in this research. *Third,* two main factors were perceived by teachers for their experience in the SSI-teaching practice, including internal and external factors. Internal factors involve self-needs, the appropriate teaching approach, and teacher skills. External factors include the advantages of classroom environment and student achievements, time requirement, as well as school community or culture. *Fourth,* it is revealed that by recognising and implementing SSI-based teaching in the framework of teacher professional learning as implemented in this research, teachers' belief was stronger as they perceived more understanding about SSIs. This dimension of teacher belief, thus, led them to the challenges of further implementation of SSI-based instruction.

## 8.3 Limitations of the Study

This research was carried out in an attempt to develop and implement an innovation, namely socio-scientific issues-based instruction in biology classrooms which is lacking in the Indonesian context. There are, without doubt, possible weaknesses in the study particularly related to the conceptual framework and the methodology. These limitations are described as follows.

### 8.3.1 Biology-curriculum orientation

Based on the author's experience conducting research in science education in Indonesia, it is a great challenge to encourage teachers as well as school communities to be involved in the development of an innovation. The first challenge is related to finding out the extent to which the innovation deals with curriculum implementation or teaching-learning practice that is ordinarily carried out in the school. As mentioned in the background (section 1.3), science education practice in Indonesia tends to place emphasis on the conceptual understanding of satisfactory students' results on the final test or examination. Therefore, any concept of innovation that is intended to be promoted, such as SSIs-based instruction in biology classrooms in this research, must be consistent with particular topics of the curriculum. As a consequence, this study only developed and implemented a small part of the biology curriculum rather than whole topics that need to be learnt by students.

### 8.3.2 Limited number of teacher-participants

The second limitation of this study relates to the context of the participants. Ethical considerations led the researcher to meet potential participants who had agreed to voluntarily participate in this research. Nonetheless, the current study finally involved four biology teachers and five classes of students in three schools. One possible advantage that arose from this circumstance was that these schools represented a variety of characteristics among the participants; two schools are located in the suburbs of the main city and the other school was in downtown Yogyakarta region. It is reasonable to assume that any interpretations made from the findings of this study may apply to other teachers and students with similar contexts as the research participants.

## 8.4 Implications

Based on the findings and limitations of the study, there are several implications for science (biology) education research, practice and policy, especially in the Indonesian context. These implications are described in the following sections.

### 8.4.1 Implication for biology teachers

There are three implications for biology teachers that arise from a reflection of the SSI-based learning environment in which the teachers as well as their students interacted with one another during this research.

First, as this research documented positive responses as well as challenges from the biology teachers toward SSI-teaching professional development, this suggests that the professional development program is feasible and should be continued. One way to take this into account is for those teachers who participated in this research to arrange a SSI-teaching development group. In the group, there would be a great opportunity for teachers to maintain their teaching belief as well as motivation in SSI-based instruction that was previously cultivated during this research by sharing their experience, knowledge, and idea of SSI-teaching. Furthermore, they can learn together to develop another SSI-based instruction program that can be further implemented in their biology classrooms. Instead of doing this effort individually, the collegial activity within the group may provide synergy in terms of sharing ideas, perspectives, knowledge, and increasing time effectiveness.

Second, still in the group, each teacher can try to transmit the SSI-teaching program towards his/her biology colleague within the same school by conducting classroom research together. Since one of the important findings of this research found that classroom culture, in which teacher has an important role, is an essential factor that influences SSI-based instruction effectiveness, the mutual classroom research is more likely beneficial to develop better biology classroom culture especially for implementing SSI-based teaching. Moreover, this effort can also be more spread out by interschool-biology classroom research program through a cooperation

involving the district biology teacher union that already existed in many areas. By developing the research networks and involving a wide range of classrooms as well as different characteristic of students, biology teachers could share their experience and knowledge for a better biology education practice in Indonesia.

The third view is related to biology instruction and assessment practice. By participating in similar research modelled in this study, biology teachers could develop more knowledge about informal reasoning skill and social-related considerations as another biology learning objectives. Awareness and willingness to apply these learning objectives may support the teacher to develop a different biology learning environment and provide an occasion for students to express their various potencies or ability. Regarding metacognitive perspective, teacher can take an advantage as students could reflect the value of their learning and, perhaps, would improve their behaviour as well as attitude for more meaningful results.

### 8.4.2 Implication for the researcher

From the research findings, the first implication that needs to be considered by the researcher is an issue related to the instrument for assessing student perceptions of SSI-based learning. According to the interview results, a few students perceived another perception which represents, or can be viewed as, the dimension of self-regulated learning. However, since the dimension was not included in the developed instrument, it is likely necessary to conduct a further research for redeveloping the instrument by putting the dimension of self-regulated learning in the questionnaire. By doing this idea, an established instrument of student perceptions of SSI-based learning would be useful for assessing the learning environment comprehensively.

For the second implication, as the researcher has been attending and involving in a biology teacher training institution in Indonesia, this research has provided valuable occasions where it is possible for the researcher to meet some biology teachers, make observation in their classrooms, and also have an in depth personal discussion about experience as well as perceptions of innovation (i.e SSI-based instruction) in

their teaching practice. Thus, researcher was able to recognize and understand any challenges, complexity, or difficulties that might be faced by the teachers when dealing with the innovation in their biology classroom especially for SSI-based instruction implementation.

For the personal perspectives, understanding those aspects would be beneficial for reviewing his role in science (biology) teacher training institution, especially for the professional responsibility to maintain the sustainability of SSI-innovation implementation. Furthermore, in regard to the institution where the researcher is belonged to, this study would really helpful as a basis of further advancing development of biology teacher training as well as biology education program.

In broader context as a part the science education research community, researcher's experience in conducting SSI-based education research would be an advantage as well as a challenge to enter and involve in global research network in this research area. It should be noticed that one of the big problems in science education research in Indonesia is a lack of Indonesian researcher involvement and publications in international scope. Therefore, by entering and involving in the research networks, there are at least three valuable meaning that can be taken. *Firstly,* the researcher might has an advanced and enriched knowledge, experience, and ability in conducting as well as publishing further SSI-studies. *Secondly*, this advantage could reinforce researcher's role in empowering SSI-innovation research in Indonesia. *Lastly*, by the research network, researcher plays an important role in bridging SSI-research from the local context (i.e Indonesia) toward global scope so that more results, interpretation, and meaning could be disseminated for this research field.

### 8.4.3 Implication for policy makers

As asserted in the results of this research study, perhaps the biggest challenge in implementing the innovation (including SSIs-based instruction) in science education practice in Indonesia is a strong curriculum emphasis on national examination. As stated by biology teachers in this research, it is a big demand

particularly for teachers to ensure that their students are ready for the tests. This implies mostly on teaching and learning culture in biology classroom all this time. Therefore, policy makers may need to review and revise current biology curriculum. As the national test places more focus on cognitive skills and does not take into account scientific literacy, reasoning skills and character orientation, it would be hard for biology teachers to pay attention to those alternative learning objectives.

Nevertheless, coincident understanding about reorientation of biology curriculum for scientific literacy goal of science education and character education between policy makers, such as department of education, curriculum authority, and school principals, with support from science education researcher as well as teacher training institutions would be a great opportunity to start a movement on developing and advancing biology education innovation in Indonesia. Furthermore, by sharing a strong commitment between school communities, department of education and teacher training institutions for enriching more research particularly in SSI-research area, it is really valuable for biology teachers to involve in the teacher professional learning program and advancing their capabilities, as described as above implication mentioned in section 8.4.1.

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## Appendix A. Participation information sheet & Consent Form

# Curtin University
# The Science and Mathematics Education Centre (SMEC)
# Participant Information Sheet

My name is Agung W. Subiantoro. I am currently completing a piece of research of my Doctoral degree of Science education at Curtin University, Perth, Western Australia. My research entitled is ***Promoting Socio-scientific Issues-based Learning in Biology: Indonesian Students' and Teacher's Perceptions and Students' Informal Reasoning.***

**Purpose of Research**

By my research, I am investigating:

1. the reliability and validity of the instrument for students' perception of socio-scientific issues (SSI)-based learning,
2. experienced biology teachers' and pre-service biology teachers' perception of SSI-based teaching,
3. students' perceptions regarding SSI based-learning on biology,
4. the type of informal reasoning that may be performed by students based on the SSI-based learning.

**Your Role**

As student;

1. I am interested in finding out of your idea about or perceptions of SSI-based learning based on the questions in the instrument. Your answers will be useful to assess the instrument which will be employed in real learning process further. How you could give your answer is explained on the questionnaire.
2. I need to find out your perceptions about SSI-based learning based on learning process that you are going to experience in class. Besides through the questionnaire, I will ask you to share your experience and perception by interview.
3. I will ask you to answer an open-ended question about a socio-scientific issue that you have learnt in the class. Your answer will represent the type of your

informal reasoning skill. There will be no right or wrong answer regarding your reasoning. How you would express your answer will be explained on the instrument.

4. The interview process will take approximately 20-30 minutes.

As teacher;

1. I will ask you to attend teacher professional development workshop on designing and implementing SSI-based teaching.
2. I would like to find out your perceptions of and experience on practicing SSI-based teaching through interview.
3. The interview process will take approximately 30-40 minutes.

**Consent to Participate**

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research.

**Confidentiality**

The information you provide will be kept separate from your personal details, and only myself and my supervisor will only have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

**Further Information**

This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval Number SMEC XXXX). If you would like to further information about the study, please feel free to contact me on +61 42-024-0027 or by e-mail: azollapinata@yahoo.com. Alternatively, you can contact my supervisor: Prof. David F. Treagust on D.Treagust@curtin.edu.au.

**Thank you very much for your involvement in this research.**

**Your participation is greatly appreciated.**

# CONSENT FORM

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- I understand the purpose and procedures of the study.
- I have been provided with the participant information sheet.
- I understand that the procedure itself may not benefit me.
- I understand that my involvement is voluntary and I can withdraw at any time without problem.
- I understand that no personal identifying information like my name and address will be used in any published materials.
- I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
- I have been given the opportunity to ask questions about this research.
- I agree to participate in the study outlined to me.

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NAME: _____
SIGNATURE: _____
DATE: _____

# Appendix B. Teacher Reflection Sheets

## SELF-REFLECTION

1. Firstly, please define a biological topic that you have experienced to teach in the class. Based on your experience, please describe the learning purpose(s) of the topic that are emphasized in the learning process and how you teach it.
   - The biological topic is:

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   - The emphasized learning purpose(s) is/are:

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   - The way I taught the topic:

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2. Have you ever taught on the issues-based topic in your biology class? **Yes / No**
   If yes, please mention what the topic was and briefly describe why you thought it was an issue-based topic?

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3. What does the phrase ‘socio-scientific issues’ mean to you?

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4. What can you describe about the term ‘scientific literacy’?

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5. What does the term ‘character education’ mean to you?

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6. Based on your view, what is the relationship between scientific literacy and character education in biology instruction?

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**JOURNAL D-1**

After attending the workshop, please describe your perceptions of or understanding about the following aspects:

1. my teaching experience and scientific literacy goal for biology education

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2. socio-scientific issues (SSI)

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3. potency of socio-scientific issues for character education in biology instruction

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4. general perceptions regarding the first day workshop discourse

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**JOURNAL D-2**

Based on the 2nd day workshop, please describe your perceptions of or understanding about the following matters:

1. the essential aspects of SSI-based teaching

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2. things that you need to prepare for teaching SSI in biology

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3. factors that need to be considered or might be challenged in addressing SSI

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4. general perceptions regarding your role as a teacher in implementing SSI instruction

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**JOURNAL D-3**

*"Based on our sharing and discussion, I view my preparation or readiness on teaching SSI in my biology class as described below"*:

# Appendix C. The Teachers Program for Introducing and Developing SSI-based Instruction

| Day & Objective(s) | Activities |
|---|---|
| **#1**<br>Objective(s):<br>Teachers are be able to:<br>1. describe their experience on how they carried out their teaching practice, especially about learning objectives, their understanding about scientific literacy and issues-based topics that pertinant to biology.<br>2. define the characteristics of SSI and their distinction with STS approach<br>3. describe various objectives of SSI and their relationship with scientific literacy<br>**4.** show understanding on the link between SSI and character education in Indonesia analyse the essential problem of an example of SSI and its conflict or dilemma | 1. As an 'ice breaking' session, teachers were asked to do a reflection of their experience on their biology teaching practice. Based on one particular topic that they have had carried out, it was expected that the reflection will describe how they emphasized-learning objective(s) of the topic and the way it was taught. Participants' perceptions of or understanding about issues-based topics, socio-scientific issues, scientific literacy and its relation with character education, were expected to be revealed as well. Self-reflection will be written-recorded.<br>2. Following previous personal activity, participants were asked to share their reflection to others orally.<br>3. The researcher showed a video of *'the dreadlocks-hair ritual'* which provides an issue about heredity and cultural belief, in Wanasaba society, Indonesia. Based on the clip, participants were asked to identify any problem or dilemma between biology and social aspects that occur in the video and to offer their opinion regarding the issue.<br>Their agreement to the issue, how to deal with the issue with biological knowledge, or whether it is sufficient for biology instruction or not, were the expected opinions to emerge.<br>4. The researcher led discussion about the basic framework of socio-scientific issues (SSI) and its role in the current worldwide science education movement. The discourse includes:<br>- the characteristic of SSI<br>- objective(s) of SSI and its relation to scientific literacy as a goal of science education.<br>- SSI-based learning which was developed or implemented in science education studies.<br>5. The discussion continued to talk about potency of SSI for biology education and supporting character education in Indonesia. In this session, participants took the Indonesian curriculum along with them. The researcher led a discussion about scientific literacy and character education in biology instruction practice that underline in the curriculum document. Attempting to make the discussion more meaningful was arranged firstly through brainstorming of participants' perceptions of or understanding on character education based on the curriculum framework. |

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|---|---|
| | 6. To gain deeper understanding about SSI requires examples of SSI in the context of Indonesia. In this occasion, the researcher led the participants to analyse and discuss a dilemma or conflict that might be emerged from a number of Indonesian-context SSI. For instance, Merapi ecosystem and water management, food import policy and Indonesia biodiversity endurance, or housing and agriculture.<br>7. As a review for the first day workshop, participants wrote down their reflections. |
| **#2**<br>Objective(s):<br>Teachers are expected to:<br>**1.** describe the pattern of SSI-based instruction model<br>**2.** construct lesson plans for SSI-based instruction program on selected biological topic | 1. For the introductory session, based on their knowledge or experience, teachers were asked to briefly describe an example of particular learning strategy pathways, such as *problem-based learning* or *inquiry learning* model.<br>Next, based on their perception or knowledge from day #1 workshop, teachers were challenged to try to figure out SSI-based learning for a particular biology topic.<br>Following the opening session, short discussion will be held to share teachers' works, particularly focusing on the distinction between prefered learning strategy and SSI-based instruction.<br>2. The researcher engaged the participants to discuss the basic framework of SSI-based instruction according some international studies. In this section, the researcher and the participants reviewed a number of SSI-based models and explore its practical aspects. Finding the pattern for a SSI-based learning model as well as modify the existing ones (if possible) was the main target of this section.<br>3. The researcher provided three prospectus topics which are expected to be implemented in further learning practice. The topics are: 1. *Global warming*, 2. *Phone cell radiation*, and 3. *Between breast feeding and formula milk*.<br>The essential issue as well as fundamental concepts that underlined the issue which are appropriate or suitable with each topic were something that needs to be discussed between the researcher and the participants.<br>4. After defining the potential issue, each teacher was asked to select one particular topic and design the SSI-based instruction based on the model framework which was discussed in advance. Either draft of lesson plans or learning materials outline were expected results from this section.<br>5. For this day #2 review, participants were asked to write down their reflection in a journal. |

| | |
|---|---|
| **#3**<br>Objective(s):<br>Teachers are be able to:<br>describe their lesson plans and share the strength and the possibilities (challenges) of the implementation. | 1. The main purpose of this day session was discussing the draft of lesson plans that have been prepared by participants. Besides the learning pathways that are illustrated in the lesson plans, the strength and the possibilities (challenges), certain practical matters such as questions set for engaging student or students' worksheet, were expected to be revealed during this occasion.<br>2. The role of the researcher was to make sure that the participants' ideas are in alignment with the SSI-based learning framework.<br>3. A personal review or reflection of the discussion was carried out as usual. |
| **#4**<br>Objective:<br>Researcher and each participant are be able to share an in-depth reflection regarding the workshop program | Interview with every teacher |

## Appendix D. Sample of SSI-worksheet

# *Global warming & my motorcycle: Do I contribute?*

**What will you learn by completing this worksheet?**

1) Reflecting on your decision how to go to school responsibly and the global warming issue.
2) Calculating the amount of greenhouse gas (GHG) emission, particularly $CO_2$, from the motor cycle you drive.

# Task 1: How is your consideration?

Nowadays, global warming has been given considerable attention in the world communities. It seems to be a known problem for everyone, perhaps including you as a student. What important things concerned with human activity in modern life today contributes mostly toward global warming through greenhouse gases (GHG) emission, such as $CO_2$ from vehicle use.
Otherwise, as you can find in our daily school-life, most of students in our region are going to school by driving a motor cycle. It can be viewed that a motor cycle driven by students may contribute to the rising of greenhouse effect and global warming events. As a member of society, how you deal with this issue?

In a group, please discuss your idea or position regarding the issue stated:

***"To confine the greenhouse effect, do you agree if a regulation from the local government to disallow motor cycles driven by students is enforced?"***

Write a strong justification paragraph for your decision about the issue. Make sure to answer the following questions to support your claim in a way that shows your reasoning.

1) Regarding the issue, do you agree if, to confine the greenhouse effect, a regulation from local government to disallow motor cycles driven by students is enforced?
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2) Whether you agree or disagree, what is the factual content to support your decision or position that can be confirmed or refuted regardless of your cultural or personal views?
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3) What ethical considerations can be included to support your decision? (economics, law, culture, respect for others, benefits, harm, disadvantage)

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4) What are the views and interests of the individuals or groups affected by the decision that you think are most relevant?

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5) What are some alternative options and why are they not as strong as your decision?

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# Task 2: Let's calculate!

Any decision that you have made in the Task #1 may represent your understanding about the relation between the habit of driving a motorcycle to school and greenhouse effect or global warming events. Moreover, you have provided such considerations that support your decision regardless of the scientific concepts or understanding that might be involved.
Through this task, you will try to have insight towards your view about whether you are potentially contributing to the greenhouse effect or not.

1) In your group, define who is or how many of you drive a motor cycle to school.
2) For each of you (student) who is driving a motor cycle, try to measure the distance of a return trip from home to school. State the range of your trip in km.
3) Based on the distance that you travelled, calculate the amount of gasoline consumed by your motor cycle with this key calculation:

   ***Gasoline consumed = range of the trip (km) / fuel economy of the vehicle (km/L)***

4) Now, calculate the emission form each vehicle used by this equation:

   ***Emission = activity[1)] X emission factor[2)]***

   **Note:**
   [1)] activity: gasoline consumed
   [2)] emission factor

| **Mode of transportation** | **Emission factor** | **Emission factor value** |
|---|---|---|
| Car | Average petrol car | 0.243 $kgCO_2e/km$ |
| Motorcycle | Average petrol motorbike | 0.143 $kgCO_2e/km$ |
| Bus | Average local bus | 0.136 $kgCO_2e/km$ |
| Train | National rail | 0.067 $kgCO_2e/km$ |

5) Calculate the total emission from all member groups.
6) Data

| Student | Return-trip distance (km) | Emission |
|---|---|---|
| | | |
| | | |
| | | |
| | **Total emission** | |

**What do you think?**

1. What did you find when you calculated the emission based on all students' motor cycles in your school?

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2. What is the meaning of your result regarding global warming issue? Are those related to each other?

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3. How could you describe the relationship between $CO_2$ emission and global warming?

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4. Based on the result of this activity, do you think that your decision on the activity 1 may be changed? Why?

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# Appendix E. Samples of Informal reasoning sheet

## INFORMAL REASONING SHEET

*Considering that one of the most motor cycle drivers in Yogyakarta are school students, do you think that for decreasing the greenhouse effect a regulation from the local government to ban motor cycles driven by students is required?*
*Please support your answer or opinion with reasons!*

# Appendix F. Teacher interview protocol

**TEACHER INTERVIEW PROTOCOL**

**A. Before SSI-teaching practice**

1. How do you think your understanding about SSI (either before or after participated in the workshop)?
   - can you try to provide an example of SSI for biology instruction?
2. How necessary do you think the implementation of SSI in biology instruction?
3. Are you interesting to teach SSI-based learning in your biology class?
   - What is your reason?
4. Are you ready to implement SSI-based instruction in your biology class?
   - (if yes) what factors make you believe that you are ready?
   - (if no) what factors impede your confidence to do it?
5. Compared to other learning approaches (which you have experienced before), do you think SSI-based learning is different?
   - (if yes) what are the specific distinctions?
   - (if no) why you think SSI-based instruction is not different?
6. If you are going to teach SSI in your biology class, what challenge(s) are you likely to face?
   - How will you deal with that?
7. Do you think what are some advantages as well as disadvantages related to implementing SSI into your biology class?
8. Are there any other ideas that you would like to share about your preparation or readiness to practice SSI-based instruction?

**B. After SSI-teaching practice**

1. After implementing the lesson, what do you think about the issue?
   - Do you think it represented a SSI?
   - Was is suitable for our curriculum?
2. So, how do you understand SSI-based instruction?
3. Compared to your regular teaching practice, what is the difference?
   - Is there any factor or issue related to your teaching style?
4. What did you see as advantage(s), or, as disadvantage(s)?
5. About teaching materials, from your experience, what do you think needs to be considered for your preparation of SSI-teaching?
6. What is the difficulty when implementing SSIs-teaching?
   - What about the challenges, or threats?
7. Are you interested to develop and implement SSI-lesson again, next time?

# Appendix G. Student interview protocol

**STUDENT INTERVIEW PROTOCOL**

1. Have you ever learnt biology like we did [with SSI] before?
2. Compared to your previous learning activity, what do you think about your learning experience like you did with SSI?
3. Did you find any challenges, or difficulties?
4. Have you tried to reconsider about biology topic that you have learnt in your daily life?
5. About the group discussion, was there any interesting things that you can share with me?
   - Have you experiences doing discussion like we did [with SSI]?
   - About your previous group or class discussion, can you please tell me about it?
6. When you were sharing ideas toward making a decision [upon the issue], did you find any difficulties?
7. When you make a decision, did you think each of you needs more information?
   - Did you have any experience on learning with seeking and examining information?
   - Did you think that the entire information you got was appropriate?
   - Did it encourage you to analyse scientific information, or argue or debate with your friends?

8. Do you think you obtained different things, besides biological knowledge?
   - About the issue, do you think it influenced your understanding about the biological concept being learnt?
9. Which you will prefer, learning biology like we did before or just doing as in common?
10. Do you think it is good or appropriate for you learning with SSI in your biology class?

## Appendix H. Students' Perceptions of SSI-based Learning Scale in Biology

***Direction***

Please circle whether you ***Strongly Disagree*** **(SD)**; ***Disagree*** **(D)**; ***Not sure*** **(NS)**; ***Agree*** **(A)**; or ***Strongly Agree*** **(SA)** for each statements. There are no 'right' or 'wrong' answer. If you want to change your answer, just cross it out and circle another.

| **Contextualization of SSIs** | **SD** | **D** | **NS** | **A** | **SA** |
|---|---|---|---|---|---|
| *In my biology class ...* | | | | | |
| 1) I learn about biology outside of school | 1 | 2 | 3 | 4 | 5 |
| 2) What I learn starts with issues related to biology in daily life | 1 | 2 | 3 | 4 | 5 |
| 3) I learn how biology can be part of my out school-of-life | 1 | 2 | 3 | 4 | 5 |
| 4) I get a better understanding of biology in daily life | 1 | 2 | 3 | 4 | 5 |
| 5) I learn interesting things about biology outside of school | 1 | 2 | 3 | 4 | 5 |
| 6) I realize that biology is relevant to my life | 1 | 2 | 3 | 4 | 5 |
| 7) I find real example of the relationship between biology and daily life problems | 1 | 2 | 3 | 4 | 5 |
| **SSIs' Learning objectives** | **SD** | **D** | **NS** | **A** | **SA** |
| *In my biology class ...* | | | | | |
| 8) I learn social values that are related to biology | 1 | 2 | 3 | 4 | 5 |
| 9) I learn how to apply my biological knowledge to respond others' opinions | 1 | 2 | 3 | 4 | 5 |
| 10) I learn how to make an adequate argument to discuss biological issues in daily life | 1 | 2 | 3 | 4 | 5 |
| 11) I learn how to make a good decision | 1 | 2 | 3 | 4 | 5 |
| 12) I learn how to concern about ethics to solve biological issues that arise in society | 1 | 2 | 3 | 4 | 5 |
| 13) I learn how to think about various aspects to solve social problems that are related to biology | 1 | 2 | 3 | 4 | 5 |
| **Attitude toward SSI learning** | **SD** | **D** | **NS** | **A** | **SA** |
| *In my biology class ...* | | | | | |
| 14) I enjoy discuss about things which disagree with my previous ideas | 1 | 2 | 3 | 4 | 5 |
| 15) Finding out about new things concerning biology is important | 1 | 2 | 3 | 4 | 5 |
| 16) I like to listen to people whose opinions are different from mine | 1 | 2 | 3 | 4 | 5 |
| 17) I find it is challenging to know about new ideas | 1 | 2 | 3 | 4 | 5 |
| 18) I am willing to change my idea when evidence shows that my ideas are poor | 1 | 2 | 3 | 4 | 5 |

| **Involvement in the SSIs learning** | **SD** | **D** | **NS** | **A** | **SA** |
|---|---|---|---|---|---|
| *In my biology class ...*<br>19) I discuss ideas in class | 1 | 2 | 3 | 4 | 5 |
| 20) I give my opinion during class discussion | 1 | 2 | 3 | 4 | 5 |
| 21) Other students listen carefully to my ideas | 1 | 2 | 3 | 4 | 5 |
| 22) My ideas and suggestions are used during classroom discussion | 1 | 2 | 3 | 4 | 5 |
| 23) I ask other students to explain their ideas | 1 | 2 | 3 | 4 | 5 |
| 24) I explain my ideas to other students | 1 | 2 | 3 | 4 | 5 |