Pre-Service Science Teachers Socioscientific Argumentation: A Decision Regarding Nuclear Power Plant

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Abstract: This study aims to explore the quality of socioscientific argumentation of pre-service science teachers (PSTs) about nuclear power plant issue in Indonesia. A total of 72 pre-service science teachers were involved in this study as the participant, which composed of 23 first-year students (FS), 28 second-year students (SS), and 21 third-year students (TS). The quality of socioscientific argumentation was analyzed by component and coherence argument aspects. The result showed that third-year students were more competent to propose an argument than first-year students and second-year students, but second-year students were more able to produce a coherent argument than first-year students and third-year students. These indicated that argumentation skills developed through the process of practice and experience, whereas the coherency of argument was affected by students' understanding of nuclear power plant concept. Therefore, learning activities should be fostering students to understand the content of science and engaging student to socioscientific issues, so they will be able to make a logical decision and argumentation when grappled with controversial issues.

1 INTRODUCTION

The development of science and technology in the 21st century produces findings and innovations those play an important role for living things. However, when the findings are confronted with society, it creates controversy and dilemma. Thus, the society should be able to evaluate and make decisions on these issues critically (Kim et al., 2014).

Many emerging issues are not only related to science but also to various aspects such as social, economic, and political. Those issues are known as socioscientific issues (SSI). SSI are controversial, ill-structured, do not have an absolute solution, but it involves moral reasoning or ethical consideration in the process of decision-making on these issues (Zeidler and Nichols, 2009, Christenson et al., 2014).

One of science goals is students are able to make thoughtful decisions about scientific discovery and socioscientific issues through the process of reasoning using scientific and social evidence (Kim et al., 2014). Socioscientific issues often occur in daily life, so students should be able to make a logical decision and argumentation by assessing the risk and benefits of alternative solutions and evaluating their evidence (Karahan and Roehrig, 2016). Argumentation plays an important role because it stimulates thinking process and reasoning, as well as reflecting the conversations which occur in the real life (Zeidler and Nichols, 2009).

The construction of nuclear power plant in Indonesia meets the criteria for a socioscientific issue because it raises the public debate about the benefits and risks which can occur due to the construction of nuclear power plant. The issue also poses a dilemma in society and even raises an anti-nuclear energy group due to possible radiation, especially after a meltdown of the Fukushima nuclear reactors in Japan (Fauzan and Schiller, 2011). Although in reality, nuclear power plant also provides benefits such as produces fewer greenhouse gases than fossil fuels that can reduce global warming (Kilinc et al., 2013). Therefore, this issue is appropriately used as a context, because it can stimulate students to be able to think critically, make wise decisions, and propose arguments with various point of view of both economic, political, social, and environmental aspects.

Some research findings on the quality of pre-service science teachers' argumentation indicate that PSTs' are able to build various argumentation

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schemes especially when they work in the inquiry-oriented laboratory (Ozdem et al., 2013). When grappling with socioscientific issues, PSTs involve personal experiences, social and social and moral considerations, and technological concerns (Topcu et al., 2011). PSTs also preferred to produce evidence-based arguments rather than intuitive-based arguments, but they failed to produce quality evidence and present different types of evidence to support their claims (Ozturk and Tuzun, 2016). In relation to the issue of nuclear energy, the quality of reasoning ability on the issue of nuclear energy utilization is influenced by students' understanding of content as well as information that used during socioscientific argumentation process (Yang and Anderson, 2003).

Some of the studies have revealed the quality of PSTs' argumentation on socioscientific issues. However, research on the quality of PSTs between educational level has not been studied, so it provides an opportunity to be investigated. Therefore, the urgency of this research is to analyze the difference of PSTs' argumentation quality among educational levels and to identify the factors which affect it.

2 METHODS

2.1 Experimental Method

We used a descriptive method to explore the quality of pre-service science teachers' socioscientific argumentation. Participants in this study were 72 pre-service science teachers, which composed of 23 first-year students (FS), 28 second-year students (SS), and 21 third-year students (TS). Data were generated through socioscientific argumentation test which contains nuclear power plant issue in Indonesia.

2.2 Data Analysis

Toulmin Argumentation Pattern (TAP) was used in this study as a basic framework to identify the component of argumentation. Based on Toulmin's framework, argumentation consists of six component: claim, data, backing, qualifier, and rebuttal (Inch et al., 2006).

To assess the quality of PSTs' socioscientific argumentation, we identified PSTs' argument through 2 aspects: 1) level of PSTs' argumentation, and 2) coherency between argumentation component. We used modified Dawson and Venville rubric (2009) to determine the level of PSTs' argumentation (Table 1) and Widodo, Waldrip, and Herawati rubric (2016) to establish the coherency between PSTs' argumentation components (Table 2).

Table 1: Level of Pre-Service Science Teachers' Argumentation.

Level	Description
1	Present a claim only
2	Present a claim and data and/ or warrant
3	Present claim, data, warrant, and backing/ qualifier/ rebuttal
4	Present claim, data, warrant, backing, and qualifier/ rebuttal
5	Present claim, data, warrant, backing, qualifier, and rebuttal

Table 2: Level of Coherency between Pre-Service Science Teachers' Argumentation Components.

Category	Description
Higher Coherency	The claim is logic and is supported by a correct and relevant *grounds* (data, warrant, backing).
Reasonable Coherency	The claim is logically made sense and is supported by a sound ground.
Limited Coherency	Claim logically make sense but no supporting grounds or the grounds is incorrect or irrelevant. The claim doesn't logically make sense and provides no supporting grounds.

3 RESULTS AND DISCUSSION

3.1 Level of Pre-Service Science Teachers Argumentation

In response to the nuclear power plant issue, all three groups of PSTs have been able to generate a claim and a reason (Figure 1). However, not all PSTs were able to propose a valid evidence to support their claim. The ability to produce argument toward nuclear power plant issue was best demonstrated by third-year students. Some third-year students have already able to provide backing, qualifier, and/ or rebuttal to the claim, so their argument can reach level 3, 4, and 5. The second group was shown by second-year students who have been able to propose arguments up to level 3 and 4. However, first-year students could only generate arguments up to level 3 that contain a claim, data, warrant, and backing.

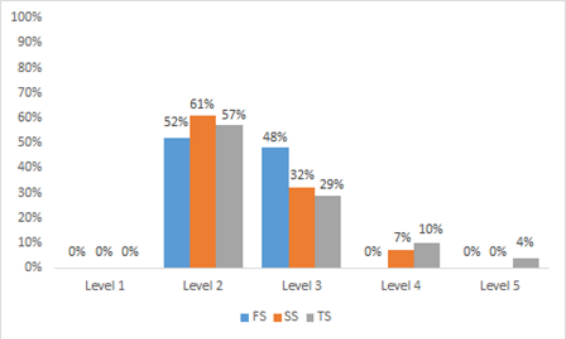

Figure 1. Level of Pre-Service Science Teachers' Argumentation

Differences in argumentation skill in the three groups of PSTs could be caused by differences in the learning experience. Third-year students studied longer in the campus learning environment than second and third-year students. Thus, the experience to proposing argument on an issue differs from second and third-year students. The findings of Khishfe (2013) showed that argumentation skill could be developed through experience to generate arguments in the learning process.

Most of PSTs' arguments in all groups were composed of claim-data-warrant or claim-warrant. They have difficulty in proposing another component to strengthen their claim, as in one of the following PST' argument:

I don't agree (claim) because nuclear contains hazardous materials and cause high radiation (data), so it can endanger our society (warrant).

Most of PSTs' arguments were based on personal consideration, without sufficient scientific evidence or relevant facts. Acar *et al.* (2010) explained that students preferred to use the intuitive conception and their reasoning if they did not understand about a qualified argument.

The difficulty of PSTs in proposing arguments also occurred in rebuttal components. This was seen in the percentage of level 5 argument which indicated by only a few of third-year students. Whereas rebuttal was a significant indicator of argumentation quality and because it against other arguments thus encouraging students to evaluate the validity and strength of their arguments (Erduran, 2007). The difficulties of students proposed rebuttal which against their theory could be caused by their belief in a topic (Acar et al., 2010).

The low presence of rebuttal as well as other components such as backing and qualifier indicated the need for integration of socioscientific issues in the teaching process to stimulate pre-service science teachers to produce a strong and qualified argument.

3.2 Coherency between Argumentation Components

In the aspect of coherency between argumentation components, most PSTs' argument in all educational level showed limited coherency (Figure 2). This indicated that argumentation of PSTs was weak since each component was incapable to support the proposed claim, as in the following argument:

Agree (claim), so Indonesia can utilize nuclear power (warrant). Indonesia has not been able to utilize nuclear power because it has no nuclear power plant (data).

In that argument, the data and warrant component were correct but the reasoning of argument was not able to support the proposed claim toward the construction of nuclear power plant, so the argument coherency was limited.

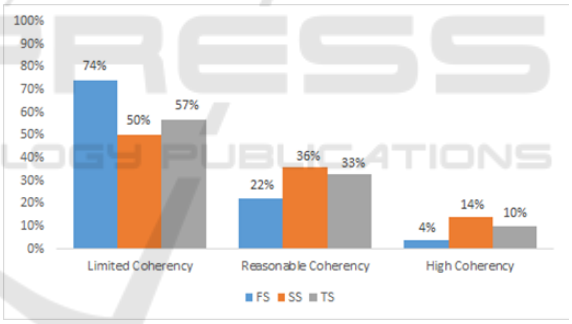

Figure 2: Coherency between Argumentation Component of Pre-Service Science Teachers.

Based on data in Figure 2, so the sequence of PSTs' argumentation quality in the aspect of argument's coherency was SS (second-year students) – TS (third-year students) – FS (first-year students) respectively. This was because most of second-year students' argument have valid grounds and support their claim, as in the following example:

Disagree (claim). Indonesia is a tectonic area (data), so if an earthquake happens, nuclear power plants can cause negative impacts such as the occurrence of radiation when a leak occurs in nuclear reactors (warrant). The Japanese nuclear power plant was disrupted by the tsunami and causing radiation (backing).

The grounds in the argument above have roles to strengthen the claim, so the validity of data and content plays a significant role in the coherency of argument. To be able to produce a quality argument, which has a high coherency, it needs conceptual understanding and good experience related to the context of socioscientific issues. This was supported by several research findings (Jonsson, 2016; Dawson and Schibeci, 2003; Yang and Anderson, 2003) which showed that the quality of students' argument has a positive and strong correlation with conceptual understanding. Although the findings of other studies (Zohar and Nemet, 2002; Cetin et al., 2014) showed that there is no significant relationship between the quality of argumentation and students' conceptual understanding. However, PSTs who did not know about the benefits and risks of nuclear power plant construction tend to propose weak arguments. Therefore, PSTs' knowledge and experiences which associated with nuclear power plant greatly help them to generate high-quality arguments.

The low-quality argumentation of most PSTs in all group (level 2 and limited coherency) indicated two things: 1) the need for a learning process involving socioscientific issues, and 2) enhancement of scientific conceptual understanding related to socioscientific issues.

4 CONCLUSIONS

Pre-service science teachers have low-quality argumentation. The third-year students were more skilled to propose argumentation component than second and first-year students. Second-year students have more knowledge of nuclear power plant than first and third-year students. Learning activities that implicate socioscientific issues were needed to improve socioscientific argumentation skills and PSTs' conceptual understanding.

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