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Socioscientific Argumentation of Pre-Service Teachers about Genetically Modified Organisms

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Abstract. This study aims to investigate socioscientific argumentation of pre-service teachers of science and non-science major regarding Genetically Modified Organisms (GMOs) issue. We used descriptive study and involved second-year pre-service teachers from two major, 28 pre-service science teachers (PSTs) and 28 pre-service non-science teachers (PNSTs) as participants. Paper and pencil test was administered in order to obtain the data of PSTs' and PNSTs' argument about GMOs. All of the data were analyzed by descriptive analysis. We applied Toulmin Argumentation Pattern (TAP) as a basic framework to identify the argumentation component. The result showed that both PSTs and PNSTs were able to propose an argument with a claim, data, and/ or warrant. Most of their argument contain data which provided in the text, without any further reasoning or relevant scientific knowledge. So, the coherency between argumentation component in both PSTs and PNSTs was limited. However, PSTs are more able to propose coherent arguments than PNSTs. These findings indicated that educational background and learning experiences may influence to pre-service teacher argumentation in the context of GMOs. Beside that, teaching and learning process which focused on the socioscientific issues is necessary to develop pre-service teachers' argumentation

1. Introduction

Socioscientific argumentation is argumentation about science issues that have social implications, involving personal decision-making and political debate [1]. Socioscientific issues (SSI) is different from other issues in science. SSI is open-ended, ill-structured, and it can be argued from various perspectives and solutions [2]. Many socioscientific issues present in everyday life, so it requires a person to make a decision on the issue. To be able to make the correct and logical decision about controversial issues, so argumentation need to get used in everyday life [3].

Argumentation skill is also required when a person enters the world of college and career, where he should be able to analyze the information contained in scientific journals, newspapers, television, the internet, or in the classroom and everyday conversations [4]. Most of the information contained in the media is information that involves various aspects of science, social, economic, political, cultural and so often leads to pros and cons. Students should be taught to be critical readers of the scientific knowledge, so they do not directly receive information from various mass media. Therefore, the



ability of a person to be able to think critically and make logical decisions about controversial issues need to be developed [5].

Genetically Modified Organisms (GMOs) is one of the socioscientific issues which still debatable. GMOs refers to organisms in which the genetic material has been altered through genetic engineering process, such as golden rice. GMOs issue involves interdependence between social and science in many respects [2], the interaction of various economic issues, ecology, social, biotechnology [5], and also moral and ethical consideration [6]. Consumption of golden rice in Indonesia still pros and cos, so this issue is used in the investigation in order to stimulate pre-service teachers in the process of decision making and develop a scientific argument.

Based on Toulmin's framework, argumentation consist of six components: 1) Claim, is presented as the outcome of the argument, the expressed opinion or conclusion that the arguer wants to be accepted; 2) Data, are arranged on facts or evidence which serve as the basis to support the claim; 3) Warrant, expresses the reasoning used to link the data to the claim; 4) Backing, composed of facts or reasoning used to support or legitimate the principles contained in the warrant; 5) Qualifier, is the specific conditions under which the claim is true; and 6) Rebuttal, states the condition that undermines the argument or opposing claims, data, and warrants [7; 8; 9].

Based on the explanation above, it is important to determine the extent of argumentation skill of pre-service science and non-science teachers, because they will face the real world controversial issues and make logical decisions on the issue.

2. Experimental Method

This research used a descriptive method to describe the argumentation of second-year pre-service teachers in a natural setting without any treatment. Participants in this study were 28 pre-service science teachers (PSTs) and 28 pre-service non-science teachers (PNSTs) of a private university in Bogor City. Data were generated through socioscientific argumentation test which contains the issue of golden rice. PSTs and PNSTs argumentation component were analyzed by Toulmin Argumentation Pattern (TAP).

In order to assess the quality and coherency of pre-service teachers argumentation on GMOs issues, based on TAP, we used modified Dawson and Venville rubric [10] to identify the level of argumentation (Table 1) and Widodo, Waldrup, & Herawati rubric [11] to analyze the coherence and comprehensiveness of the argumentation components (Table 2).

Table 1. Level of Pre-Service Teacher's Argumentation

Level	Description
1	Present a claim only Example: I will consume golden rice (<i>claim</i>)
2	Present a claim and data and/ or warrant Example: I will consume golden rice (<i>claim</i>) because it contains beta carotene that will change into vitamin A in my body (<i>data</i>), so it can help me to prevent night blindness (<i>warrant</i>).
3	Present claim, data, warrant, and backing/ qualifier/ rebuttal. Example: I will consume golden rice (<i>claim</i>) because it contains beta carotene that will change into vitamin A in my body (<i>data</i>), so it can help me to prevent night blindness (<i>warrant</i>).
4	Present claim, data, warrant, backing, and qualifier/ rebuttal. Example: I will consume golden rice (<i>claim</i>) because it contains beta carotene that will change into vitamin A in my body (<i>data</i>), so it can help me to prevent night blindness (<i>warrant</i>) because vitamin A is important for eye health (<i>backing</i>).

Table 1. Cont.

5	<p>Presents all components of argumentation: claim, data, warrant, backing, qualifier, and rebuttal.</p> <p>Example: I will consume golden rice (<i>claim</i>) if it has passed the test (<i>qualifier</i>), although genetically modified rice is not natural (<i>rebuttal</i>). Golden rice contains beta carotene that will change into vitamin A in my body (<i>data</i>), so it can help me to prevent night blindness (<i>warrant</i>) because vitamin A is important for eye health (<i>backing</i>).</p>
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Table 2. Level of Coherency and Relationship between Argumentation Components

Category	Description
Higher Coherency	<p>The claim is logic and is supported by a correct and relevant <i>grounds</i> (data, warrant, backing).</p> <p>Example: I will not consume golden rice. There are some vegetables and fruits which rich of vitamin A, such as carrot, spinach, broccoli, and papaya, so it can supply the body's need for vitamin A. In addition, the price of golden rice can be more expensive than conventional rice.</p>
Reasonable Coherency	<p>The claim is logically made sense and is supported by a sound ground.</p> <p>Example: I will not consume golden rice because I can get vitamin A from carrots and other vegetables.</p> <p>Claim logically make sense but no supporting grounds or the grounds is incorrect or irrelevant.</p>
Limited Coherency	<p>The claim doesn't logically make sense and provides no supporting grounds.</p> <p>Example: I will not consume golden rice because I like local rice.</p>

3. Result and Discussion

3.1 Level of Pre-Service Teachers Argumentation

Both pre-service science teachers (86%) and pre-service non-science teachers (96%) showed the ability of argumentation in level 2 (Figure 1). They were able to propose a claim on golden rice, along with data and/or warrants. However, most of the pre-service teachers have not been able to apply for further reasoning and deep understanding of GMOs issue. This is indicated by the presence of the submitted data is the data which contained in the context of the issue. Both PSTs and PNSTs mostly did not apply the scientific knowledge of genetic engineering in their argument. Most of them did not discuss the other aspects in addition to the context of the golden rice, such as the impact to the environment, or to the economy of local farmers. Thus, the highest argument of both pre-service teachers is level 3 (claims, data, warrants and backing/qualifier/rebuttal). None of the arguments were in level 4 and level 5.

Participants who rarely proposed the component backing, qualifier and rebuttal also occur on Osborne et al. research [10], where participants rarely expressed the rebuttal in their argument. Whereas the presence of rebuttal is a significant indicator of the quality of the argument because the rebuttal encourages participants to be able to evaluate the validity and strength of argument [12].

Although both groups of pre-service teachers indicated the level of argumentation on level 2 and 3, based on their argument proportion, PSTs' argument have lower proportion on level 2 and level 3 than PNSTs'. This indicated that PSTs performed better on the argumentation of genetically modified organism than PNSTs.

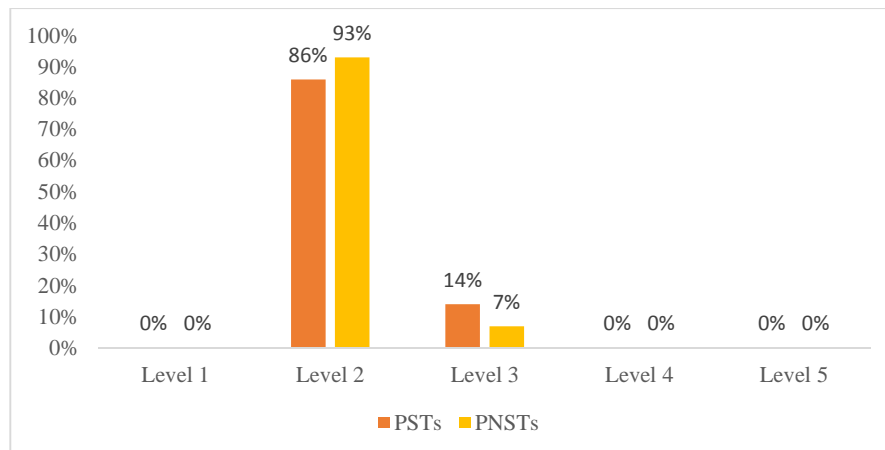


Figure 1. Level of Pre-Service Teachers Argumentation

3.2 Coherency between Argumentation Components

Pre-service science teachers showed a more coherent argument than the argument of pre-service non-science teachers (Figure 2). It can be seen on the deployment of PSTs' argument. The limited coherency and reasonable coherency argument of PSTs' were lower than PNSTs'. In addition, PSTs have been able to argue that relatively high coherency when compared with PNSTs. This can be caused by a different learning experience with PNSTs PSTs. PSTs least knowing about genetically modified organisms as a form of genetic engineering. Differences in experience and knowledge that allowed for differences in the process of reasoning and arguing about GMOs. The results of this research in line with Lin [13] that the science students had an average score significantly higher than non-science students in the use of evidence.

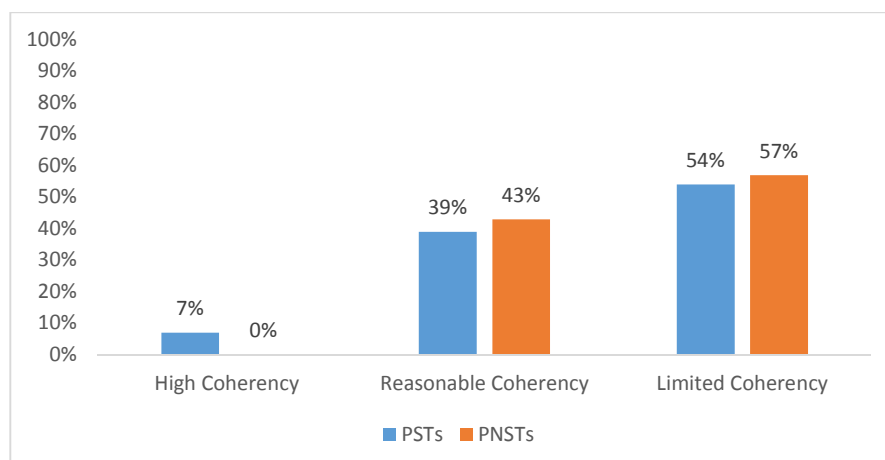


Figure 2. Coherency between Argumentation Components

In response to issues related to GMOs, most of PSTs and PNSTs argument was limited coherency. Data or warrant that they have did not support their claims, so the strength among the components of

argument was weak. Some pre-service teachers also filed arguments with irrational reasons or invalid evidence. This showed that they have not been able to make logical decisions on controversial issues. Sadler and Zeidler [2] suggests that the socioscientific issues can be particularly difficult for a person to negotiate, because SSI is an open-ended, ill-structured, and debatable. Therefore, an individual needs to understand the issues they face in order to make good decisions. The ability to reason, think critically, understand and argue with a logical and coherent manner both orally and in writing allows a person to be able to participate fully in public life [9].

Pre-service science teachers' argument categorized limited coherency (54%) had a slightly different proportion with the PNSTs argument (57%). Based on their arguments, only some PSTs apply their scientific knowledge related to genetic engineering to support the claim and do deeper reasoning on the issue of GMOs.

These findings showed that the scientific knowledge which has been acquired by PSTs about genetic engineering may influence their argument over the issue of GMOs than PNSTs. This is reinforced by the findings of Lewis and Leach [14] that the ability to reasoned of genetic engineering issue is requires understanding of the relevant science, and also influenced by the context and personal experience.

Many arguments of pre-service teachers which are at a low level and limited coherence demonstrated that argumentation skill needs to be built and developed at the university level. This is due to the habit to expose evidence, reason, and the other correct and logical supporting can be trained especially during the learning activity [15]. In addition, the integrated teaching SSI can provide a positive impact on students' understanding of science content [16]. Students need to consider the risks and benefits of each alternative solution, ask questions, evaluate the evidence, and make good decisions, so preparing students with the understanding, skills, and value needed to grapple with socioscientific issues is very important [9].

4. Conclusion

Most of the arguments of PSTs and PNSTs were at the level 2, where the argument was only made up a claim, data, and/or warrants on the consumption of golden rice. Most of the arguments in the two groups of pre-service teachers also have a limited coherency. This was because the data or warrant that they put forward was not valid or irrelevant with his claim. Therefore, the teaching process that focuses on developing argumentation skills on socioscientific issues need to be implemented, so the pre-service teachers can make logical decisions when grappled with controversial issues in the real world.

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