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Students' Scientific Reasoning About Global Warming

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Abstract

This descriptive study aims to explore scientific reasoning of junior high school students about global warming. Participants of the study were 32 seventh graders, 32 eighth graders, and 28 ninth graders from multinational school who administered scientific reasoning test and interview. Students were interviewed to explain their reason and evidence which support their arguments in the scientific reasoning test. In addition, students' questionnaire was also collected and analysed. Scientific reasoning was analysed through students' arguments. Toulmin Argumentation Pattern (TAP) was used to identify the component of argumentation, which consist of claim, data, warrant, backing, qualifier, and rebuttal. Then, the analysis of students' arguments involved two aspects: the argumentation components and the strength of argument. The result showed that most students' arguments (73%) in all grades were consist of claim, data, and warrant only (level 2) without backing, qualifier, and rebuttal to support their claim, and most students' arguments (47%) in all grades were weak, which means that the ground of argument (data, warrant, backing) were not support their claim. The finding of this indicated that learning activities should provide students with scientific process which emphasis on engaging students to reason because scientific reasoning can be developed through training.

INTRODUCTION

Science teaching is an active process which involves students to think how scientific concepts acquired and applied in the daily life. The NRC (Dolan & Grady, 2010) recommends that students engage in cognitive process that typify scientists' thinking, such as asking scientifically oriented questions, giving priority to evidence in responding to questions, formulating explanations from evidence, connecting explanations to scientific knowledge, and communicating and justifying explanations. Involvement of students in the cognitive process is very important to train students so they are able to reason scientifically. Scientific reasoning includes the thinking skills involved in inquiry, experimentation, evidence evaluation, inference, and argumentation (Piraksaa, Srisawasdib, & Koulc, 2014). In the science teaching, scientific reasoning is one of important skills because scientific reasoning involved in several processes such as analysing/ solving problems, integrating/synthesizing parts, designing/planning explanations, drawing conclusions, generalising, evaluating, and justifying, and applying these capacities to unfamiliar problems (Waldrip, 2012).

Students' scientific reasoning skills can be identified through their output, argument. At the time of reasoning, students produce and evaluate the reasons which would strengthen their argument to convince others. Students also have to reveal strong evidence so their argument can be accepted. Reasoning in children is mainly manifested in their arguing with someone else and scientific reasoning involves and develops from abilities in argumentation, including abilities to identify and evaluate different points of view

(Bekiroglu & Eskin, 2012). During the discussion, a student may have similar or different explanation with other students. They propose an explanation for each along with the reasons and evidence that they have, so the rationality of science is founded on the ability to construct persuasive and convincing arguments that relate explanatory theories to observational data (Yang & Tsai, 2010).

Argumentation is a form of discourse which includes a reasoning process and promotes critical thinking (Bekiroglu & Eskin, 2012). Science which is characterized by a process of generalization theories/ hypothesis and hypothesis testing through the process of argumentation (Yang & Tsai, 2010). In analyzing students arguments, Toulmin's Argumentation Pattern (TAP) is still used as a basic reference for many researchers. The components of argumentation as reasoning from data to arrive at a claim by using warrants that tie the evidence to the claim, considering additional supports for the warrant, and proposing qualifiers of and rebuttals to the claim (Bulgren, Ellis & Marquis, 2014).

In the structure of TAP, its components have its function (Inch, Warnick, & Endres, 2006; Simosi, 2003): 1) The claim is presented as the outcome of the argument, it refers to the expressed opinion or conclusion that the arguer wants accepted, 2) the data are arranged on facts or evidences which serves as the basis to support the claim, 3) Warrant expresses the reasoning used to link the data to the claims, 4) Backing composed of facts or reasoning used to support or legitimate the principles contained in the warrant, 5) Qualifier is an adverb that indicates the rational strength the arguer attributes to it, and 6) Rebuttal states the condition that undermine the argument.

Scientific reasoning habits are also important in daily experiences since they provide important ways to make rational and sound judgments about controversial issues in social contexts (Yang and Tsai, 2010). When students deal with controversial issues, students need to make decision on what should they do by revealing evidence and reasons to support their decision. So, when students reason about controversial issues, students can show the reasoning which includes the construction of supporting argument, counter-argument and rebuttal (Wu and Tsai, 2011). One of issues that can be used to trigger students' scientific reasoning is global warming. Global warming are widely talked and the effects can influence to all of are in our society, so it need to be instructed in school science (Nuangchalem & Kwuanthong, 2010). Beside that, teaching science is not only referring to the lesson, but also social interaction in terms of controversial between science and society are stimulated and need to incorporate into school (Nuangchalem & Kwuanthong, 2010).

Based on the research problems outlined above, two research questions guided the design of this research:

- 1) How is the argumentation components of the 7th, 8th, and 9th graders' argument?
- 2) How is the strength of 7th, 8th, and 9th graders' argument?

RESEARCH METHODOLOGY

This research used descriptive method to describe the condition of students' scientific reasoning in natural setting without any treatment. Data were generated through scientific reasoning test, students' interview, and students' questionnaire with a total of 72 junior high school students from 7th grade (32 students), 8th grade (32 students), and 9th grade (28 students). Analysis of students scientific reasoning involved two aspects: the component of argumentation and the strength of argument. The students' arguments were divided into claim, data, warrant, backing, qualifier, and rebuttal based on Toulmin Argumentation Pattern (TAP). The component of argumentation was measured by a modified rubric of Dawson & Venville (2009), which classified the students' ability of argumentation into

level 1, level 2, level 3, level 4, and level 5 (Table 1). While the strength of argument was measured by a rubric that developed by researchers, which classified students' argument into weak, strong enough, and strong (Table 2) based on the validity of the concept, the rationality of statement, as well as the relevance of claim with the grounds (data, warrants, and backings).

Table 1. Rubric to Measure the Level of Students' Argumentation Component

Level	Description
1	Claim only.
2	Claim, data, and/ or warrant.
3	Claim, data, warrant, and backing/ qualifier/ rebuttal.
4	Claim, data, warrant, backing, and qualifier/ rebuttal.
5	Claim, data, warrant, backing, qualifier, and rebuttal.

Table 2. Rubric to Measure the Strength of Students' Argument

Category	Description
Strong	Claim is logic, supported by true* and relevant grounds (data, warrant, backing).
Strong enough	<ul style="list-style-type: none"> • Claim is logic, supported by some true and relevant grounds. • Some claims are logis, supported by true and relevant grounds. • Some claims are logic, supported by some true and relevant grounds.
Weak	<ul style="list-style-type: none"> • Claim is logic, the grounds are true, but the grounds are not relevant with the claim. • Claim is logic, but it is supported by false and irrelevant grounds. • Claim is not logic, but it is supported by true and relevant grounds. • Claim is not logic, supported by false and irrelevant grounds. • Claim is not supported by grounds.
*) The term 'true' is based on the validity of concepts and the rationality of answer.	

RESULTS AND DISCUSSION

Students' scientific reasoning which identified through the arguments were acquired by written test and interview. Interview of students aims to explore the reasons and evidence that used by students to support their argument. A total of 184 students' arguments (64 arguments from 7th graders, 64 arguments from 8th graders, and 56 arguments from 9th graders) were analyzed based on aspect of argumentation component and the strength of argument. The result of analysis of students' argumentation component is presented in the Figure 1. Based on the Figure 1 below, most of students' arguments in all grade were level 2, which means that students only able to generate claim with the data and/ or warrant without backing, qualifier, and rebuttal. This result also similar to the result of Dawson and Venville (2010) and Ekanara (2013), where most of students just generate a claim with data and/ or warrant.

Low students' ability in argumentation can occur because students are rarely involved in the argumentative discussion. As expressed by students, that teachers are rarely give problems/ issues for them in learning activity. Teachers are rarely ask for their evidence and reason. In fact, the teacher acts as an initiator in an argumentative discussion through a series of questions (Osborne, 2001), prompting students to generate data, warrants, backings, qualifier, and also rebuttal. The finding of Bekiroglu and Eskin (2012) also showed that the quantity and quality of students' arguments increase with their

involvement in the argumentation. Thus, the activity which trigger students to produce argument as well as argumentative discussion need to be carried out by teachers so the students are stimulated to be able to reason and generate their arguments. The scarcity of students who involved in argumentative discussion led to students are not able to generate the argumentation components such backing, qualifier, and rebuttal, so none of students' arguments in the level 4 and level 5 (Figure 1).

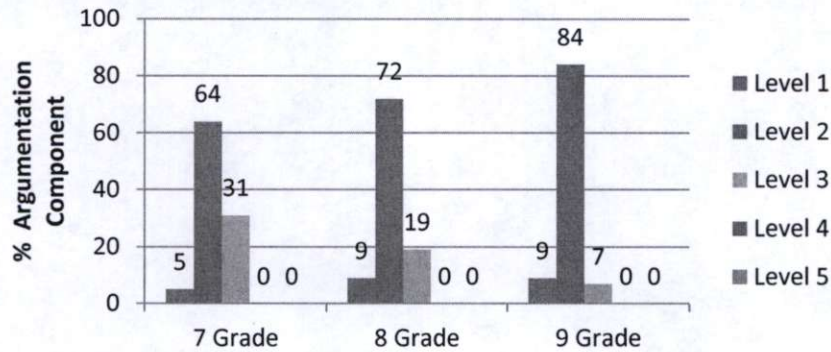


Figure 1. Percentage of Students' Argumentation Component

In the Figure 1 also showed that the ability of students to generate the argumentation component increase only at level 2 due to the higher grade levels. While the level 3 (claim, data, warrant, backing/ qualifier) is more expressed by 7th graders' arguments than 8th graders or 9th graders. This condition can be caused by students learn global warming concepts in grade 7, so 7th graders were able to generate claim, along with data, warrants, backing/ qualifier compared to 8th graders and 9th graders.

The strength of students' argument was measured by the criteria of validity of the concept, rationality of answer, and the relevance between claim with the grounds (data, warrants, backing). In the aspect of the strength of argument, most of the students' arguments about global warming were weak (Figure 2). This showed that there is still many students' claim which is not equipped with correct and relevant grounds.

Producing valid grounds (data, warrants, and backing) was associated with students' understanding of scientific concepts. A student, who has a good understanding of the concept, can adduce the evidence or correct scientific data so it can be a relevant basis for his claim. However, the high strength of students' arguments in the weak category in almost all grade levels showed that there are still many students who have not been able to put forward the valid and rational of scientific concepts. Previous study (Foong & Daniel, 2010) showed that more than 80% of students' argument contains improper or irrelevant scientific knowledge in the natural classroom setting. This result is supported by other study (Yang & Tsai, 2010) that students often had difficulty in making and justifying arguments and scientific claims because of their knowledge and their level of cognitive development is not enough.

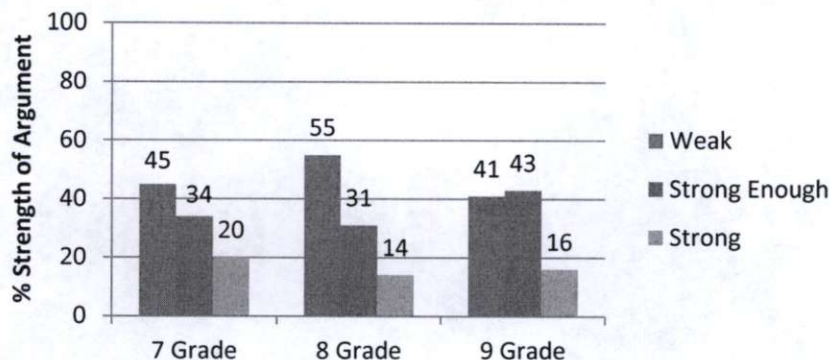


Figure 2. The Strength of Students' Argument

The number of students' argument which categorized as weak argument also due to the learning activities do not emphasize students to generate arguments particularly on socioscientific issues. Other study (McDonald, 2014) revealed that argumentation which rarely effectively incorporated in science classrooms can be caused by most classrooms are teacher dominated, with students given few opportunities to learn about, or engage in argumentation, and teachers generally do not possess adequate skills to teach argumentation to their students. This condition causes students are not accustomed to reason and argue with strong evidence and true scientific concepts.

CONCLUSION

Students' scientific reasoning which identified through the aspect of argumentation component and the strength of arguments in this study indicated that most component of students' arguments in all grade were level 2, and the strength of students' arguments were weak. Classroom activities that emphasize on the argumentation and scientific reasoning process should be accustomed, so that students are trained to generate a claim accompanied by true and relevant grounds (data, warrant, and backing), because science education is not only aims to produce students who are competent in the aspect of knowledge, but also competent in some skills that needed in students' daily life such as argumentation skill which involves reasoning.

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