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SCIENTIFIC EXPLANATION ABILITY OF PROSPECTIVE TEACHERS THROUGH THE DRIVEN INQUIRY BASED ON ARGUMENTS

Sumarno[1)], Fenny Roshayanti [2)]

[1.] Biology Education Program of UPGRIS
[2.] Biology Education Program of UPGRIS

ABSTRACT

The research was conducted in order to investigate the development of scientific explanation capability of biology prospective teachers after obtaining debriefing of scientific inquiry skills through learning framework argumentation promoting scientific inquiry skills (APSIS). APSIS learning implementation involves students in investigations project of plant development structure. Subjects were 33 first-year students participants of the plant development structure course. Data of the scientific explanation ability was obtained through the assessment of project reports investigation of plant development structure. The results showed the using of the argument framework in debriefing of inquiry scientific skills showed an increase in the ability of scientific explanation.

Keywords: argumentation, scientific explanation, scientific inquiry

INTRODUCTION

The idea to involve the students in scientific investigation was they were able to develop an understanding of the nature of science by conducting investigations (NRC, 1996). Lederman et al. (1998) states that engage students in inquiry was not sufficient to develop the students' ideas about the nature of science. Sandoval and Reiser (2004) stated that efforts to reform inquiry based learning should emphasize the value of the scientists process to generate and validate the knowledge arising from the epistemological commitment to knowledge recognized as scientific knowledge.

Scientific inquiry refers to the procedures used by scientists to study natural phenomena and to make explanations based on evidence obtained through the investigations. White and Frederikson (1998) stated that scientific inquiry was defined as the process of asking questions, generalizing the data based on experimental results and systematic observation. Pedagogical context placing inquiry as a series of instructional activities that put students involved in activities to develop their knowledge and use scientific ways of working to find an explanation of natural phenomena based on an investigation to gather scientific evidence. (National Research Council, 2000).

The ability of scientific inquiry implies a number of epistemic aspects in obtaining knowledge. Sandoval (2003) states that the epistemic aspects of scientific inquiry include knowledge of the questions that can be answered through an investigation, the relevant method in the disciplines to obtain data and how to analyze and interpret the data, including explanations, models, and theories. Instructional put on aspects of epistemic before an investigation can help the student to understand and to perform better investigation, as well as providing a clear context to examine the relevance epistemological which underlying investigation.

Forms of scientific explanation formulated by scientists around certain phenomena are limited by their investigation questions. In general, scientific explanation framed in the investigation process begins with a particular question (White & Frederiksen, 1998). Thus the scientific explanation was an answer of the investigation question and it has an epistemically important relation. Evaluation to assess the scientific explanation with regard to the value in answer to the question of the investigation, even when a new explanation is generated based on the question, they were still trying to answer the questions which posed by scientist (Sandoval & Reiser; 2004).

The main activity of the scientific explanation was to coordinate the data pattern with causal claims about the meaning of the data. Construct scientific explanations, students must choose a representative data as evidence, and then connect them with the specific causal claims. It will distinguish between claims and evidence to emphasize strategies like investigation aims to produce evidence against the claims of knowledge (Sandoval & Reiser; 2004).

Scientific inquiry was often described as the process of building knowledge through various plausible explanation that fits the data. This explanation then presented in a peer community to be criticized, debated and corrected (Driver et al., 2000; Sandoval & Reiser, 2004). Thus the inquiry based science learning involves argumentation as a very important part of communication skills for support (Briker & Bell; 2008). Enduran (2008) stated that the arguments supporting the enculturation into practice the scientific culture and to develop epistemic criteria for evaluating knowledge and supporting the development of reasoning, in particular in the election theory or attitude determination based on rational criteria. Implementation of the argument as a learning strategy determines the epistemic aspects of the investigation more explicit can improve students' ability to investigate and to support the development of their epistemological (Driver, Newton, & Osborne, 2000. Thus the argument process plays an important role in exercising scientific inquiry skills.

Argumentation process was a conceptual process that can develop conceptual understanding (Sadler, 2006) and support the process of cognitive and metacognitive occurrence (Jimenez and Erduran, 2007). Duschl et al., (2008) suggests that students need to develop some important understanding and able to participate in scientific argumentation. First, a student must be able to use an important conceptual structure (ie theories, models, and legal or a combination of concept) and cognitive processes when they were reasoning about a problem. Secondly, a student should know about science epistemic framework to develop and to evaluate the claims. Third, a student must engage in scientific argumentation and social processes of how the knowledge and skills that are communicated, displayed, discussed and debated in science.

Instructional design applied in the study sought to put the argument as a way to help students criticize in every stage in the steps of scientific inquiry. It can be said that argument was also as a tool to provide driven for student in conducting inquiry by the formulation of the problem, designing an investigation to constructing a scientific explanation. Thus, it expected to help put aspects of epistemic practices of scientific inquiry at the front of the investigation so that it can help students to understand, to investigate better, and to provide context explicitly to examine the underlying epistemological commitments (Sandoval and Reiser; 2004). This learning called a learning framework argumentation promoting scientific inquiry skills (APSIS). Then from it with this study specifically to assess the ability of the scientific explanation of how student in putting instructional arguments as driven inquiry at every step of scientific inquiry.

METHODS

One shot case study research was did in order to describe the development of the scientific explanation ability of biology student after obtaining debriefing of scientific inquiry skills through learning framework argumentation promoting scientific inquiry skills (APSIS). Subjects were 33 first-year students participants of the plant development structure course. APSIS learning implementation involves students in investigations project of plant development structure with the following topic.

Table 1. Topic of course

Number	**Plant structure**	**Topic**
1	root	Topology relation of root and its habitat
2	stem	Variety of stem architecture in plant
3	leaf	Pattern of leaf development based on veins structure and leaf shape

Data of the scientific explanation ability was obtained through an assessment of the plants development structure investigation project report that assessed with a matrix for evaluating complexity of reasoning during scientific inquiry (CSRI Matrix), which was adapted from the Golan and Grady (2010), as in Table 2 below.

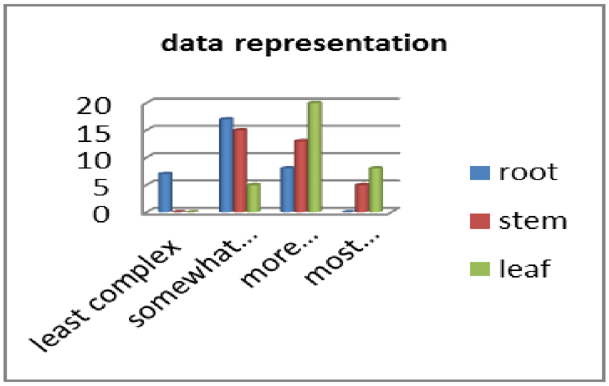
Table 2. CSRI Matrix (adapted from Dolan & Grady, 2010)

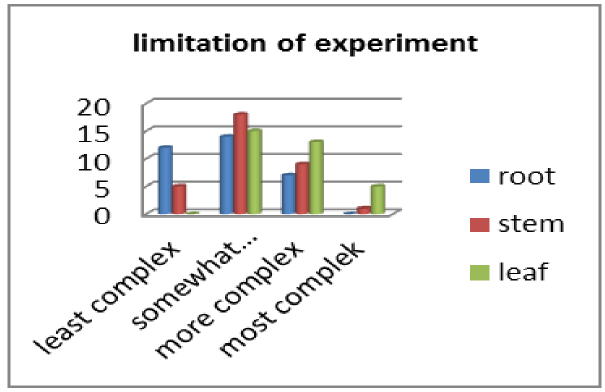
Scientific expalanation aspect	Score			
	1	2	3	4
Considering the meaning of the representations of data	Students are provided with a formatted data table and do not consider meaningful representations of data	Students design their own data tables giving little consideration to the meaning of representations of data	Students represent data in multiple ways including tables, drawings, graphs, photographs, or statistical representations with little consideration of the meaning of representations	Students represent data in multiple ways including tables, drawings, graphs, photographs, or statistical representations, thoughtfully considering the meaning of representations
Considering the limitations or flaws of their experiments	Students do not consider or report limitations or flaws of their experiments	Students consider superficial limitations or flaws of their experiments at the end of the inquiry and report these limitations	Students thoughtfully consider limitations or flaws of their experiments during the inquiry but do not make adjustments in inquiries.	Students thoughtfully consider limitations or flaws of their experiments during the inquiry and adjust inquiries accordingly.
Connecting data to the research question	Students do not connect data to research questions	Students use their data to answer questions other than the primary research question	Students use different forms of reasoning (e.g., contrastive, deductive, inductive) to connect data to the primary research question. Reasoning may require inferences involving several layers of connections	Students use results from different studies, as well as different forms of reasoning (e.g., contrastive, deductive, inductive) to connect their data to the primary research question. The reasoning may require inferences involving several layers of connections
Providing suggestions for future research	Students do not pose suggestions for future research and do not suggest additional hypotheses	Students pose superficial suggestions for future experiments or suggest unrelated hypotheses	Students pose relevant suggestions for future experiments or suggest additional, pertinent testable hypotheses	Students pose relevant suggestions for future experiments, including pertinent testable hypotheses
Communicating and defending findings	Students do not communicate or defend their findings in writing	Students give limited attention to communicating and defending their findings in writing	Students communicate their findings in writing with some emphasis on defending their findings	Students communicate their findings in writing. Students use logical arguments to defend their findings

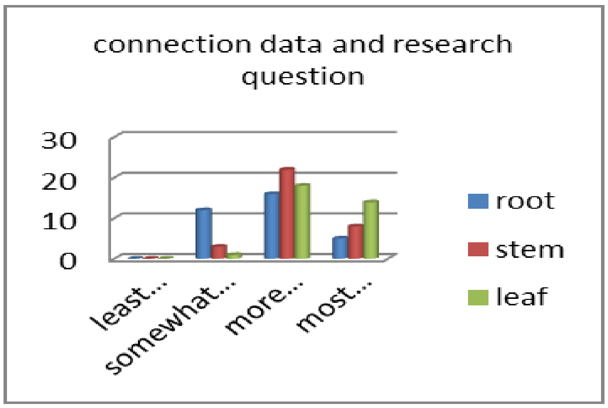
Next to describe the ability of scientific explanation, then the quantitative data were analyzed descriptively.

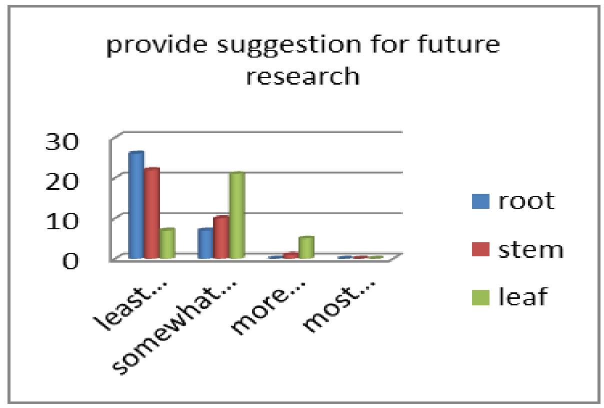
RESULTS AND DISCUSSION

Expalanation scientific capabilities described in the complexity of the reasoning used by the students. Aspects that are assessed include considering the mean of the data representation, considering the limitation of experimentation, connecting the data and research question, provide for future research and defending of finding. Analysis results described in Figure 1 and Table 2 below.









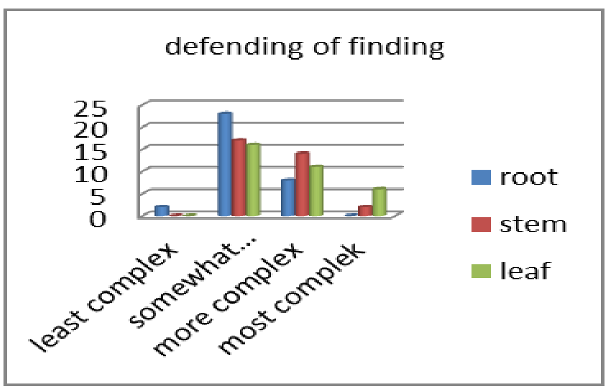


Figure 1. Complexity of reasoning in scientific explanation.

Table 2. Average of scientific explanation ability

aspect of scientific explanation	root		stem		leaf	
	mean	SD	mean	SD	mean	SD
data representation	2.03	0.68	2.52	0.62	3.09	0.63
limitations of experiments	1.85	0.76	2.15	0.67	2.64	0.70
conencting data and research question	2.73	0.67	3.15	0.57	3.39	0.56
provide suggestion for future research	1.21	0.42	1.36	0.55	1.94	0.61
defending of finding	2.18	0.53	2.48	0.57	2.70	0.77

Based on the graph in Figure 1, the student's ability to interpret data based on the representation of data in form of table, image, or photograph. Students were yet fully use statistics to represent data that has implications for the ability to interpret data. The ability of student to identify the limitations of the investigation needs to be improved. Based on Figure 1, it was only a small part of students who show more and most complex criteria. It was allegedly that student was not full using argument in the design of the investigation or at least the students have not been using metacognitive skills to assess the design of its investigation so as to find weaknesses or limitations of the investigations conducted as expressed by Jimenez and Erduran (2007) should have been arguments supporting the occurrence of cognitive processes and metacognitive.

The number of students who achieve high criteria of more complex reasoning on connecting aspects research question (showed on table 2). This indicates that the student has used a variety of ways to draw inferences based on the results of the investigation. That was the pattern of argumentation discourse students practice how the data obtained was used as evidence to support the claim based on the results of the investigation. This was consistent with the opinion of Enduran (2008) that the argument supporting enculturation into practicing scientific culture and developing epistemic criteria to support the development of reasoning, in particular in the election theory or attitude determination based on rational criteria in making a scientific explanation, using a conceptual structure that was important (ie theory, models, and legal or a combination of concept) and cognitive processes when they were reasoning about a problem (Duschl et al., 2008).

However, many students who have not been involved in suggesting further investigation based on the results of the investigation. The using of argumentation discourse develop epistemic criteria for evaluating the knowledge used in scientific explanation (Enduran; 2008). This means presumably because they feel no need to suggest further investigation, because they do a limited investigation to fulfill the project tasks.

The using of argumentation discourse in scientific investigations contribute to the student maintaining its findings in scientific communication. Patterns of argumentation encourage students to present their scientific explanation argumentatively with the support of the evidence and the theory which support their findings as a claim. Allegedly there was a relationship between student's ability to link data with inquiry questions and the ability to defend their findings (see Table 2). Argumentation process was a conceptual process that can help develop conceptual understanding (Sadler, 2006), a person involved in scientific argumentation and social processes of how the knowledge and skills that were communicated, displayed, discussed and debated in science (Duschl et al., 2008).

Although yet to meet many expectation, the using of the argument discourse as a framework in scientific inquiry learning approach, student's ability to make scientific explanations indicate progress, as shown in Figure 2.

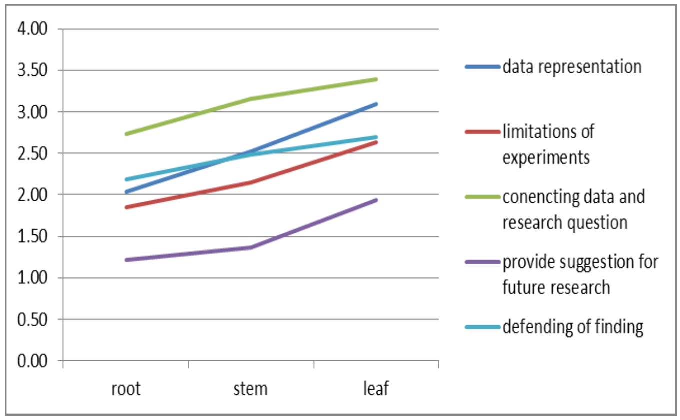


Figure 2. The development of scientific explanation in some topics.

Thus the using of the argumentation discourse in scientific inquiry transform students into practice scientific inquiry, especially placing the student in understanding the epistemic. Arguments can provide driven for students in doing inquiry with the formulation of the problem, designing an investigation to make scientific explanation. Placing aspects of epistemic practices scientific inquiry at the front of the investigation so that it can help students to understand and to investigate better, and to provide context explicitly to examine the underlying epistemological commitments (Sandoval and Reiser; 2004).

CONCLUSION

The using of arguments discourse on each step in the scientific investigations contribute to improve the ability of scientific explanation, especially in the aspect of linking the data with the inquiry questions and an attempt to defend the findings of the investigation in communication. There were increasing of the development so it suggested to use arguments in driving inquiry as well as to evaluate the epistemic status in a scientific investigation by the student.

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