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Improving Scientific Argumentation Through The Hierarchy Of Inquiry

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Abstract: This study examined how students' scientific argumentation changed over as they participated in hierarchy of inquiry learning. The hierarchy of inquiry is a comprehensive approach in which students working for an extended period of time that integrated several ways of inquiry systematically to investigate and respond to a complex question, problem, or challenge. This action research was conducted in Biology Teacher Education Program Faculty of Teacher Training and Education Sebelas Maret University. The students, who were at the 4rd semester and who studied the class of Plant Embryology, were purposely selected. The data were collected from interviews with the researchers, classroom observations, and collection of student portfolios. The scientific argumentation was measured using modified Toulmin's Argument Pattern (TAP) with four kinds of argument elements: claim, evidence, reasoning, and rebuttal which presented in oral and written. The results showed that students who experienced with the hierarchy of inquiry performed better scientific argumentation which reflecting their higher-order thinking abilities. We conclude that hierarchy of inquiry is possible in fostering student's scientific argumentation, doing some inquiry activities, and thus make a positive impact on scientific argumentation ability . The findings can be helpful in the process of designing the new curricula for teacher candidates in order to foster scientific inquiry.

Keywords: hierarchy of inquiry, scientific argumentation, science curricula, higher order thinking

1. INTRODUCTION

The progress of science and technology requires a lot of human resources spry, agile, and reflective whivh has a high level thinking skills so as to create an innovative new breakthrough, both in theory and practice. In line with the application progress of inquiry, many educational actors who began focusing on improving the ability of argumentation. Argument is an important requirement that must be mastered in science because science studying not only sees how natural law works, but also to be able to explain how natural phenomena occur and how it goes in the future.

Osborne, Erduran, and Simon (2004) states that learning science allows the discussion about the facts obtained and nature prevailing theory that argument is very important in shaping the science knowledge. As an integral part of the science, the argument should be integrated as a component of learning science. In view of sociocultural emphasizes the social interaction in the process of learning and thinking, the ability to think critically honed through discussion, an argument and exchange of experience among students ((Norris, Philips, and Osborne, 2007; Okumus, Seda and Suat Ünal, 2012) . This makes the argument should be taught in a structured learning science, and implemented in the learning activities of science as an argument in science has a unique character that distinguishes it from other disciplines. In the perspective of social activity argue tertama focused on the interaction between personal where someone tried to give exposure of the statement or the particular matter. What matters is how he can convince others that his opinions are acceptable reason, evidenced by the relevant evidence and reason, because it is the skill of looking at a problem Multiperspective by using as much as possible evidence in support. This is usually an obstacle for students and teachers of science.

An argument is essentially a set of assumptions that is accompanied with the

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settlement on the grounds that a clear and structured. Assuming the premise of the argument, and the results obtained from the various possibilities often called the statement (claim). The existence of the reasons underlying an argument makes a claim justification given. In relation to the scientific argumentation, a claim is not merely an opinion or idea is simple, but it is also a conjecture, explanation, or an answer to a problem. The reason used to support an answer, while the evidence needed to support a statement that is based on an observation or research (Besnard and Hunter, 2008; Norris, Philips and Osborne, 2007)

In science, a claim may be conjecture, inference, explanation, or a descriptive statement that answers the research problem. Evidence as part of the argument refers to the results of measurements, observations, or other relevant research findings that have been analyzed and interpreted by the researcher. Data collection should be adapted to the needs of research, for example to see whether there is a trend over time, the difference between groups or treatment, or the relationship between variables. Furthermore, the data were analyzed to support the explanation of the problems examined and compared with existing literature and similar studies that have been done previously, if any. Justification an argument expressed in a statement that explains the relevance or proof or data obtained in accordance with the theories, principles, concepts, or underlying assumptions. Students need to be given an understanding that there are some kinds of evidence and reason better than others, and the quality of an argument depends on how they formulate all the arguments appropriately component (Llewellyn, 2013). A good scientific argument must include the reasons for acceptance or rejection and the adequacy of the evidence used to support or oppose a claim.

Duschl, Schweingruber and Shoes (2007) states that the mastery of science must meet several aspects, namely; 1) has a scientific explanation of nature, using it to solve the problem, 2) build and develop scientific explanations and scientific argument, 3) understand the nature of science and how science knowledge is built, 4) understand the language of science and want to play a role in the practice of science as inquiry and argumentation , All these characters unfortunately has not been developed in the learning of science.

Interviews with high school biology teacher in scope in Surakarta showed that the main problem in science learning is limited willingness, capability and facilities required students to develop higher order thinking skills. This is compounded by the lack of skilled teachers manage learning science can enhance students' thinking skills. Most teachers assume that the inquiry in the sciences already accommodated if the students can understand the concepts and facts of science, but they do not pay attention to whether students can relate the concept and the fact that in real life or real problems going on around them. As a result of learning biology students often only considered as a collection of a concept, not an integral part of real life.

To develop students' knowledge of science, learning science in the classroom should always be developed according to the trend of the latest knowledge so that required teachers to support students in constructing and supporting scientific knowledge through strong arguments and able to teach their students how to judge other people's statements or arguments. Design appropriate learning are indispensable so that the student gets the widest possible opportunity to develop scientific reasoning, based on the data, valid evidence and the fact that they get themselves or from the research that has been tested previously (Sampson and Sharon Schleigh, 2013). Furthermore, students can make an argument that clearly, answering questions or argue with other statements, and change the statement based on new evidence that they received.

The above problems indicate the need for new innovations in the learning of science, especially biology that can maximize the ability of argumentation and skills of inquiry students so that learning biology is not just presenting concepts and facts, but simultaneously monitor how the students think, how they find a problem, how to find answers valid, presented its findings to the others and is responsible to the scientific statement issuance. Scientific argument can be seen when the students had a discussion or write scientific reports after doing research, both in laboratory and field.

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This study starts at the problems faced by the students of Biology Education University of March, namely how to make a quality argument, both orally and in writing. As a prospective biology teachers, they are required to be able to study biology that supports higher order thinking skills (HOTS), which among other things is characterized by the ability of the scientific arguments. Facts on the ground indicate that the ability of high school students' argument is weak because the teacher does not condition the learning that support the argument, as evidenced by the scarcity of teachers giving problems or questions that contain the conflict. Results of interviews with a number of teachers indicate that they give problems or issues that contain conflicts due to limited knowledge about what and how students experience the process of thinking through the arguments. In other words, the teacher can only teach the scientific arguments if they are already accustomed to. This makes scientific argumentation skills a must for prospective biology teachers, so there is no awkwardness when they actually get on the field as a Biology teacher.

On the other hand, as a Biology teacher candidates, inquiry-based learning experiences are crucial given the close relationship between learning science by inquiry activity. Inquiry is a way to understand science as a whole, in which learners learn how to solve problems based on data and facts. Inquiri term itself can refer to two criteria, namely what students should learn (inquiry based learning) and what to teach teachers (inquiry-based teaching). Through the inquiry learning experience, prospective teachers can critically reflect on pedagogical practices and make effective decisions related to the class. Inquiry should always take place continuously and comprehensively embodied in learning activities. Skills of inquiry can not happen instantly, but gradually in accordance with the experience of learners.

Wenning (2011) states that the inquiry-based learning covering divided into a tiered spectrum, from low level to high level. Failure on the initial level will give a negative effect on the next level. For students, the meaning of inquiry in science include the ability and understanding built through his students when conducting the process of scientific investigation. It is characterized by the activities of students in asking, observing, measuring, designing experiments, perform reasoning based on concrete evidence and communicate their results to others. Teachers and prospective teachers must have a thorough understanding of the hierarchy of inquiry as a whole so that they can more easily help students reach the level of scientific knowledge appropriate nature of science. During this time of inquiry-based science learning sometimes are not fully focused on the proceedings that occur.

Hierarchy Inquiry is a learning model of science that systematically includes instructions to develop the intellectual capabilities and processes of science through a systematic and comprehensive inquiry (Wenning, 2007, 2010, and 2011). Tiered inquiry consists of the lowest levels in the form of discovery learning, interactive demonstrations, lessons inquiry, inquiry labs, and a hypothetical inquiry. Discovery learning, helping students develop concepts based on direct experience of the teacher. Interactive demonstrations help teachers identify, confront and resolve alternative concepts. Inquiry lessons to guide students to identify scientific principles or relationships. Inquiry labs allow students to construct an empirical law based on the measurement variable. Hypothetical inquiry allows students to obtain an explanation of the observed symptoms. By using a tiered inquiry, students have the opportunity to make observations, formulating predictions, collect and analyze data, build a scientific concept, synthesize laws and theories as well as making and testing hypotheses for an explanation.

Inquiry tiered provide a framework for inquiry-based instruction through the spectrum of its own inquiry that inquiry-based learning is no longer considered a complicated process and disjointed but done systematically as a series of hierarchical related to the ability of the process of science.

In relation to the ability of a scientific argument, all the processes experienced during hierarchy of inquiry is expected to further sharpen intuition, broaden their horizons and to condition the prospective teachers to stimulate students in looking at a case of science through a variety of perspectives, as experienced by real scientists when it finds a problem, formulate, seek solutions, researching and analyzing what it

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finds so as to form a valid statement and acceptable to all walks of life. This is what underlies chosen learning model Hierarchy of Inquiry to be implemented for prospective biology teachers, primarily to improve the skills of scientific arguments orally and in writing.

This study focused on examining Biology Education students 'skills of argumentation scientifict both oral and written as well as examining how students' abilities to construct scientific arguments changed over. The goal of this study was to support students in justifying Reviews their claims using evidence and reasoning, considering multiple alternative explanations, and building on and critiquing the explanations of Reviews their classmates.

2. METHODS

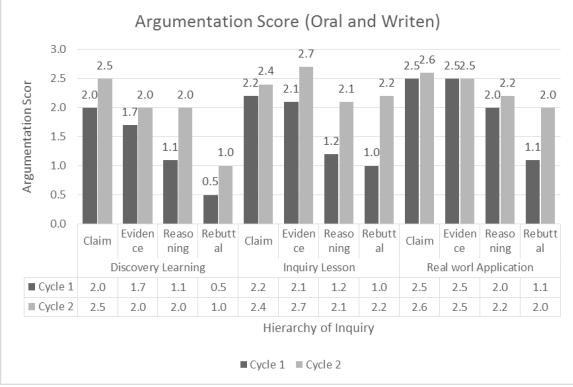
This research was conducted in an Action Research on 34 students of 4th semester 2014/2015 in Biology Education, Sebelas Maret University who were taking courses in Plant Embryology. Learning is completed in two cycles. Although there should be 6 level of inquiry, this study only accommodate three levels of inquiry alone is discovery learning, inquiry lessons and real world application for adjusting the time, materials, instructional media and student readiness. Each cycle of applying the hierarchy of inquiry consisting of discovery learning, inquiry lessons and real world application. Inkuri the first level, ie discovery learning which includes activities questioning, observing, classifying, formulating concepts, Estimating, drawing Conclusions and communicating results. The next level is the inquiry lesson, include collecting and recording the data, constructing a table of the data, designing and conducting scientific investigations and describing relationships. Last level is the real-world application, which includes collecting, assessing and interpreting the data from a variety of sources, constructing logical arguments based on scientific evidence, making and defending evidence-based decisions and judgments and clarifying values. Projects awarded in the form of argumentative writing scientific about embryology plant material applied on apomixis, Parthenocarpy and protoplast fusion then presented individually in the classroom. The scientific argumentation was measured using a modified Toulmin's Argument Pattern (TAP) with four kinds of argument elements: a claim, evidence, reasoning, and rebuttal (Toulmin, 2003), the which are presented in oral and written. Assessment arguments on each aspect scores were divided into three categories, namely high (3), moderate (2) and low (1).

3. RESULTS AND DISSCUSSION

Argumentation is very crucial in shaping critical thinking and in-depth understanding of the complex issues (McNeill, 2011). Not all opinions can be categorized as an argument. In general, a statement can be categorized as an argument if it is supported by the evidence, reasoning and strong support. This makes many students find it difficult when the lecturer gives matter or case-based material.

This study measures the aspects of students' scientific argumentation both in writing and orally. The student writing and presentation were coded using the arguments structure, Consist of claim, evidence, reasoning, and rebuttal using five different levels: 1, consists of arguments that are a simple claim; 2, consists of claims with the data, warrants, or backings, but do not contain any rebuttals; 3, consists a series of claims with the data, warrants, or backings with the occasional weak rebuttal; 4, consists a claim Clearly identifiable with a rebuttal, and; 5, displays an extended argument with more than one rebuttal (Erduran et al., 2004).

Data capabilities scientific arguments is presented below:



Graphic 1. Scientific Argumentation Score

The table above shows the increase in scores of scientific argumentation in all aspects at all levels of inquiry, on discovery learning, inquiry lessons and real world application. Results in the classroom observation showed that although at first the students have not been able to adapt to the learning provided, the hierarchy of

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inquiry makes the cognitive load is reduced so that the inquiry activity increased gradually. The advantages gained are more college students to enjoy the learning process, unencumbered and most of the students admitted that even though a given task more and more, they are even more motivated to build and develop the appropriate scientific arguments of their respective characters.

Differences in scores of scientific arguments on discovery learning as the first level of inquiry, occurs because each student has a different initial knowledge. Students from senior high school that category relative seed has prior knowledge about reproduction of plants are better than others because of the support of teachers and school facilities more complete. In cycle 1, the lecturer gives freedom to the students to make the reviews written about the character of the male reproductive organs in Angiosperme and presented individually. Although students require additional guidance from lecturers at the time of the task, the ability of oral arguments and writing began terbina. At the time of inquiry lesson, the lecturer gives the task of writing a scientific article that is supported by activity in their own laboratory in the laboratory on female Angiosperm gametophyt. The resulting scientific article resembles practicum report, but supported by the results of relevant research, and then presented. Furthermore, on the third level, which is a real world application, students review why some species reproduce vegetatively although it has a generative organ. Two cycle hierarchy is done by applying the same inquiry, but with a different topic, namely apomixis, Parthenocarpy and protoplast fusion. Generally, scientific argumentative oral and writing scores increased compared to previous cycles. This is likely to occur because students are more accustomed to making scientific articles are argumentative and simultaneously present.

The research proves that the stimulation ability through scientific argumentation task of writing and scientific presentation allows students to understand science as a process, not just science as a product. As a prospective biology teachers, the experience is what they would later teach his students. Interviews with students showed that the greatest difficulty in making scientific literature is how to choose key information in a literature and express their understanding. This is especially the case when they use the foreign language literature. The limitations of language make more missconception, consequently arguments built to be weak, and even can be dropped easily by others. Students' skills in making citasi and combine it with the knowledge that has been owned previously seen in argumentative writing that they make. At first many students who successfully made the claim and provide the data needed, but they failed to provide appropriate evidence and reasoning, especially if they are less precise selecting appropriate literature sources or out of date. In this case the student together with a team of faculty conduct group discussion forum for the perception of how to formulate good arguments. Although at the beginning of the cycle there are still many students who have difficulty in assembling claim, evidence, reasoning and rebuttal, in the second cycle they seem more confident to write their ideas

They get the experience and knowledge gained through textbooks or the research article meraka pour in writing. Not all students are able to find the case interesting is happening around them, however they generally admit that there are many interesting phenomena regarding plant embryology is happening around them.

In general, the students admit that they feel more motivated and stimulated to berinkuiri with the application of the hierarchy of inquiry in the learning they do, however, time-intensive makes them quite overwhelmed and exhausted. This creates a hierarchy of thought that the application of this inquiry should begin to be conditioned according to the needs and readiness of students so that they can enjoy the experience berinkuiri significantly and at the same argumentation skills training in learning.

The success of the actual inquiry can not be separated from knowledge previously owned. Students who diligently read scientific articles and other learning resources tend to be more successful than those without, including arguing skills. This is in accordance with the opinion of Levy and Ellis (2006) which states that the argument is essentially initiated by the onset of an underlying problem whether an investigation can be carried out or revised. The time of learning, not everyone has the same view of the line of thought that there was a problem when discussing the mutual claims or discuss a topic.

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Claims can be accepted must contain a strong argument and refers to problem solving (Osborne, 2010).

The research proves students more easily expressing ideas, arguments and their new understanding in writing and orally after following the hierarchy of inquiry learning. However, this study still needs to be assessed and evaluated, especially if it will be implemented in the learning of science in senior high school. Toughest obstacle is the length of time that is required in practically learning because students spend a lot of time outside of school to enhance their work. In addition, the implementation of the hierarchy of inquiry would be more effective if combined with curriculum support and qualified human resources.

4. CONCLUSION

The results showed that students who experienced with the hierarchy of inquiry performed better scientific argumentation which reflecting their higher-order thinking abilities. We conclude that hierarchy of inquiry is possible in fostering student's scientific argumentation, doing some inquiry activities, and thus make a positive impact on scientific argumentation ability . The findings can be helpful in the process of designing the new curricula for teacher candidates in order to foster scientific inquiry.

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