Process of Argumentation in High School Biology Class: A Qualitative Analysis

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Abstract. Argumentation skill can be nurtured by designing a lesson in which students are provided with the opportunity to argue. This research aims to analyse argumentation process in biology class. The participants were students of three biology classes from different high schools in Surakarta Indonesia. One of the classroom was taught by a student teacher, and the rest were instructed by the assigned teachers. Through a classroom observation, oral activities were noted, audio-recorded and video-taped. Coding was done based on the existence of claiming-reasoning-evidence (CRE) process by McNeill and Krajcik. Data was analysed qualitatively focusing on the role of teachers to initiate questioning to support argumentation process. The lesson design of three were also analysed. The result shows that pedagogical skill of teachers to support argumentation process, such as skill to ask, answer, and respond to students' question and statements need to be trained intensively. Most of the argumentation found were only claiming, without reasoning and evidence. Teachers have to change the routine of mostly posing open-ended questions to students, and giving directly a correct answer to students' questions. Knowledge and skills to encourage student to follow inquiry-based learning have to be acquired by teachers.

1. Introduction

The 21st century is an era of globalization, marked by the advancement of science and technology. Advances in information and communications technology in this century freed everyone to access information around the world. The 21st century requires the global community to have a good scientific reasoning to dealing with every aspect of life that has always been associated with science. Scientific reasoning plays important role in the problems solving process [1], facilitating communities to understand and applying the science in daily life.

Scientific reasoning can be trained through the nurturing of the argumentation skill. According to Sadler & Fowler, developing students' scientific reasoning can be done with the verbalizing argumentation using social-scientific issues [2]. Scientific argumentation skill contributes to produce, evaluate and advance scientific knowledge [3]. Scientific arguments constitute formal evidence-based arguments [4] to generate a knowledge involving the coordination of data, claims and evidence [5]. The arguing is one of the most complex thinking skills in the learning process [6]. Learning by developing the argumentation skill aims to introduce scientific literacy to prepare students to face the future [7].

Argumentation skill is important to develop in the learning process, because it can change the students' concept understanding in biology. Biology learning process facilitates students to learn and to find a concept by applying scientific methods. The argumentation skills include aspects, such as claims (statements that address), evidence (scientific data to support a statement) and reasoning

(justification related statements and evidence) [8]. The argumentation skills are used to repair and rebuild ideas based on scientific evidence for better understand the reality that occurs in nature as well as to provide a statement reinforced by reason and evidence to support the claim.

Factual condition in education practices in Indonesia indicates that the Indonesian students' argumentation skill needs to be improved. One research shows the profile of high school students in Indonesia tend to arguing improperly and without supporting evidence [9], and small number of students who can arguing correctly based on the information and the theory [10]; [11]. Based on the results of scientific literacy score of Indonesian students in PISA 2012, Indonesian students' argumentation skill in science also needs to be trained more.

The low argumentation skill is due to teaching and learning activities do not provide the opportunity for students to arguing. The learning activities in class are dominated by teachers that tend to control the class by explaining the learning material too much and ask questions that do not lead students to arguing. The majority of questions asked by teacher are questions that require short answers, or rhetorical questions. Therefore, it is less accommodating student to arguing. Implementation of teacher-oriented learning process makes the students are not able to master the concept independently. Weak concept mastery led to a lack of a student's arguing skill. Therefore, the learning process carried out by the teacher needs to be modified in order to engage students in arguing.

The solutions for that problem is by implementing the learning activities that guide students to argue through the scaffolding or the provision of assistance by teacher. A research by Zembal-Saul states that the evidence-based arguments can be enhanced through the argument scaffolding and argument frameworks [12]. Meanwhile, according to McNeill & Krajcik, teachers can provide support for students to develop the argument in the scientific explanation by the following ways: 1) create an explicit framework, 2) discuss the reasons for the scientific explanation, 3) modeling to construct scientific explanations, 4) discusses the similarities and differences with daily scientific explanations, 5) provide opportunities for students to develop a scientific explanation, 6) provides an opportunity for students to criticize the other students' explanations and 7) provide feedback to students [13]. Teacher is a key figure in learning to engage students in the process of argumentation to develop the ability to argue. Therefore, the ability of teachers to lead students to argue through the scaffolding should be good.

Scaffolding is a guidance or direction given by adults or people who are more competent to assist children to doing their activities [14]. Scaffolding is the approach proposed by Vygotsky stating that the scaffolding is done at an early stage to encourage students to study independently by providing direction, encouragement, warning, describing the problem in solving steps, providing examples, and other measures that enable learners learning independently [15]. Scaffolding is given in the early stages of learning and will be reduced gradually and suspended until the student can complete the task independently [15]. Scaffolding in argumentation provided by the teacher by sharing the example of ways to arguing with the statement delivered along with the reasons and evidence, and provide questions that lead to answers in the form of a statement with reasons and evidence. Scaffolding which engage students in arguing will be reduced gradually when student began to assert arguments independently with minimal guidance from the teacher, and then stopped when the students are able to argue independently. Scaffolding by teachers to students in the process of arguing is expected to guide students to arguing independently. Therefore, teachers should be able to provide the appropriate scaffolding to help students develop their argumentation skills.

2. Experimental Method

Three classroom action research (CAR) had been done simultaneously from February to April 2016, in three different classes of three different high schools in Surakarta and Karanganyar, two regencies in Central Java Province, Indonesia. The first CAR (A class) was an action research done by researcher (lecturer of university), and student teacher as the role teacher, who has actually learnt pedagogical content knowledge during their 3-years pre-service teacher training, and did three-months internship at the target school. The second CAR (B class) was collaboratively done by the researcher, student

teacher with similar experience as the one in the first CAR, and teacher with more than 10 years work experiences. The third action research (C class) was conducted simultaneously by the teacher who have 4-years experiences, student teacher, and researcher. All lesson designs were prepared collaboratively by student teacher and teacher, guided by researcher. The first research was set on the topic of Plantae (Grade 10), the second CAR was Reproductive System (Grade 11), and Kingdom of Animalia was selected as the topic of the third CAR (Grade 10).

All CARs followed the cycles of action research introduced by Kemmis & McTaggart, which was started with the reflection of teacher and students of the previous condition and practices of learning, and continued with analysing the pre-action situation. Many problems had occurred and found during the previous learning process, and researcher, student teachers, and teachers finally decided to focus on how to improve students' argumentation process, since the occurred of dialogic argumentation was identified very rare during the process of learning.

The first CAR used an Assessment for Learning (AfL) as the primary action to improve argumentation of students. The action was consistently applied for teaching Plantae in one month or 3 hours per week (1 hour equals to 45 minutes). AfL is commonly known as the divergent assessment which will give students a challenge to do self-evaluation, and allow them to know and decide what the criteria of assessment that they have to accomplish. Teacher also gives feedback to students based on students' works, and furthermore advise students to find solutions in advanced learning on the topic that students do not understand well. AfL in this research was described in the first meeting as students directly know what the target they are expected to be acquired. At the end of each meeting, teacher gave students a couple of argumentative questions and asked students to answer it, and sometimes students brought it back as homework.

Meanwhile, the second CAR opted to develop a lesson design based on the syntax of lowest level of inquiry models, i.e. discovery learning, as the main interrupted action in each cycle to nurture argumentative skills of students. The design of lesson followed the syntax of discovery, and learning experiences in each cycle was flourished with the various of animal specimens, that student teacher provided. Since school does not have those specimens, student teacher borrowed them from the Laboratory of Department of Biology Teacher Education Sebelas Maret University. Invertebrate was taught prior to the vertebrate, and students were encouraged to discover the characteristic of classification in invertebrate, and discuss what the basis or determinants that scientist use to classify invertebrate. The same activities done when students learned about vertebrate.

Data of dialogic argumentation was noted, and audio-visual recorded. All dialogues in each cycle were analysed to know whether the students and role teacher have developed a sequence of argumentation in their oral activities during the learning process. The simple of McNeil and Krajick model of argumentation, which consists of three aspects of argumentation, i.e. claiming (C), reasoning (R), and evidence (E) was applied to identify the fact of argumentation.

3. Result and Discussion

Learning process before the action research was observed randomly, and all dialogues during a 45 minutes' class were noted. It shows that no sufficient argumentative dialog during the learning process. The dialogue on the beginning of the learning process is displayed in Table 1. The A class, which taught by student teacher on the topic Kingdom of Plantae, indicates the lack initiative of role teacher to encourage students to do argumentative dialogue. By asking student with a question: "What do you know about the Plantae?", it seemed that teacher expected students will response with more than single answers. One student answered briefly that Plantae is plant (in original language student used Indonesian language for plant as tumbuhan). There are two words in Indonesian language commonly used to translate the word plant, i.e. tumbuhan (from the basic word tumbuh or to grow), and tanaman (from the basic word tanam or to plant). In Indonesian terms, plants are the one which grows without human effort, and the one which is planted or cultivated by human. Role teacher in this case, tried to furtherly confirmed student's concept about the plant, however student thought the simple

point by mention about the common colour of plant. At the end, another student suggested about the photosynthesis, which is a main determinant to differ plant from animal.

At the B class, which was learning about the Plantae too, teacher started the dialog by directing student to talk about spermatophyte or seed plants. Argumentative sequences are not available in this dialog, since teacher asked the open-ended question, and always confirmed and directly corrected students' answers. The same situation is also found at the C class, where teacher taught the digestive system and brought student to discuss on disturbances in digestive process. In this class, role teacher also seems to quickly moved to the main topic, without providing students with sufficient space and time to gradually think and understand the concepts.

Table 1. Comparison dialogue in the beginning of the learning process at pre action research.

A. Role Teacher: Student Teacher (Expository model with AfL)	B. Role Teacher: Teacher and Student Teacher (Discovery model)	C. Role Teacher: Teacher (Guided Inquiry Model)
T: What is in your mind when you hear the word Plantae? S: Plants, Ma'am (C) T: Plants, that like....? S: Plants that green colour, Ma'am (C) T: Is it just green? S: No, there are red, brown, and yellow (C) T: Does anyone else want to argue about plants? S: A living being, photosynthetic, a lot of type, Ma'am. C T: (show picture moss) Is this image also includes plants? S: Yes, that's the moss, lichens, including plants, Ma'am	T: Let's talk about habitat and life adaptation of spermatophyte. T: Where is the habitat of seed plants? S: On the ground, in the pots (C) T: Yeah right, on the ground, in the pots, in the water... T: And then.... T: Seed plants are usually found everywhere T: What the character of plant? S: Antagonist (C) T: No, isn't. Spermatophyte is photoautotroph, because they have a chlorophyll to photosynthesize T: for example.....	T: Is there anybody ever experienced diarrhea? S: Yes, we are (answer by some students) (C) T: Is diarrhea a disturbance in digestive system? S: Yes, Mam (C) T: All right, what the topic that we will learn today? S: Digestive system disorder (C) T: Exactly, we will learn about disturbances in digestive system T: Today we will immediately form the discussion groups. Please look for a variety of disorders of digestive system. Then find out the causes, prevention and treatment. Your time is 20 minutes, so please make the groups

Description: The symbol "C" indicates the claiming, "R" indicates *reasoning* and "E" indicate the *evidence*

After three cycles of action research (almost 4 weeks), the argumentative dialogue still did not improve significantly (Table 2). However, teachers had tried to use the question word, "why" or "what is the reason", which are the type of stimulus questions to encourage students to accomplish their claims with the reasoning behind. Student teacher at the first class action research (A case), try to always ended questions with a question tag, and students have been trained to make claiming followed by its reason. These types of dialogue are probably influenced by the AfL, which give students a sort of assessment, such as 2-tier assessment, in which students were trained weekly on doing some argumentative questions, and how to always strengthen their answers with a good reasoning and evidence. A 2-tier test might be consisted of multiple choice or essay test. In the multiple choice type, students have to choose a correct answer and follow it by selecting the correct reason. Meanwhile, in the essay test, student have to write the answer and also its reason. This treatment probably has a good effect on how students and teacher develop an argumentative dialog. Moreover, students also got the feedback of their works a week after, hence the argumentative skills of students are kept on the right track, as mentioned by McNeill & Krajcik [13].

The different pattern found in the second action research (B case), where students had not directly state the claiming followed by reasoning. It can be noticed that students always mentioned the reasoning soon after the teacher asked them to come with the reason. Interestingly to analyse the snapshot dialog among students in a group, when they discuss about Aves. It is absolutely great to start argumentative dialog when one student said, "Why did the chicken can not fly even though they have the wings while the birds can?" This question forced other students to think the characteristic of both birds and chicken, and make sure the distinguished point. Students are also try to always find an evidence of their opinion, and teacher had reduced her provisions to always directly answer students' questions.

However, the role teacher at the third action research (C case) still confused on how to pose questions to trigger the argument of students. Teacher also did not understand well what the different between reasoning and giving evidence, as she asked the following question, "There is relation between lungs and TBC. What the evidence is?" It seems students faced a bit puzzlement at the moment, as he answered, "The existence of bacteria". And the conversation became more unclear, when the teacher continued asking the reason of student's claim. Student did not have a chance to understand why bacteria can be a cause of TBC. One student had tried to define what TBC is, and how bacteria are able to infect human lungs, and caused TBC. It can be concluded that teacher could not keep the sequences of argumentation, as some scholars argued [16].

Table 2. Snapshots of the dialog at the last cycle

Role Teacher: Student Teacher Action: Expository model with AfL	B. Role Teacher: Teacher and Student Teacher Action: Discovery model	C. Role Teacher: Teacher Action: Guided Inquiry Model
T: The statement that the angiosperm is gymnosperm is true or false? S: Yes, angiosperm is gymnosperm (C) T: *Cyperus rotundus* and *Eulisine indica* are monocots that included in the group of Graminae. The statement is true or false? S: That's true, because the morphology between the two is almost the same as characteristic of the Graminae (C R) T: Dicotyledonous plant plays a role in human life, one of them in the health field, is this a true statement?? S: Yes, ma'am, because it can be used as medicine/remedies such as lime is used for cough (C R E) T: Today we will learn about the latest material on the Plantae, the gymnosperms. What do you know about by gymnosperms? S: Plant with open seed (C)	T: Have you visiting the zoo? T: Come on ... who wants to argue ... hands up! T: What do you think about vertebrates? S: Similar to Adit, Ma'am...(C) (nick name of *one student*) (C) T: Yeah, right. So is Adit also vertebrates? S: Yes. (C) T: What?? Why did you Adit include as vertebrates? S: Because he has skull. (R) T: Yes, he has cranium. T: Besides that, what do you know about vertebrates. What do you think distinguishes vertebrates to invertebrates?? S: The Vertebrates have endoskeleton, and invertebrate do not. (R) ------------------ S (36): Why did the chicken can not fly even though they have the wings while the birds can? S (16): They could... But only to a certain short distance only. (C) S (34): No, they can't. T: Can anyone answer her?	T: Depending on what the cause. Because of a bubbling in the alveoli. What was the causes of tuberculosis (TBC)? S: Genetic or heredity and also lifestyle (C) T: Lifestyle. Then, what else? S: Bacteria. (C) T: The bacteria also exist. Could be in the form of infections and non-infectious. That's the conclusion of the first and the second. The third conclusion. How about the TBC, the hypothesis is accepted or not? S (19): Yes, ma'am, there is a relationship between the lungs with tuberculosis. (C) T: What organs are attacked? S: Lungs. (C) T: Well, so there is a relationship between the lungs with tuberculosis.

T: Are these images including plants gymnosperms? S: Yes, Ma'am, (C) T: Then, what are the characteristics of the gymnosperms? S: They have Strobilus, ma'am (C) S: Yes, Strobilus, which is in this image? S: That browny cone shape, in pine (C)	S (33): They can't, but bird can, because they have an air bag. (E) S (34): air pocket. 8 S (9): Because the bird has an air pocket when it flew, different from the chicken, they not have the air pocket. (E) S (16): Because most of chickens is terrestrial. (R) S (20): The chicken did not have airbags. (R) S (3): So they can not fly. (R) S (31): Why did the chicken has the syrinx? S (16): No, they do not have. (C) S (33): Bird have that. (R) S (16): Syrinx is for singing. (R)	What the proof of that statement? S: The presence of bacteria. (C) T: What is your reason? S: According to the journal obtained earlier mentioned that tuberculosis is a disease of the respiratory system, caused by bacteria that get into the respiratory organs. Then, the bacteria that cause dysfunction in the lungs. So that the lungs do not function properly. (R E)

Description: The number in parentheses is the number of the students, while the symbol "C" indicates the claim, "R" indicates *reasoning* and "E" indicate the *evidence.*

The process of argumentation depends on many factors, such as what kind of the trigger questions to start the argumentative answers or statements that lead the conversation between teacher and student, or students and their peer. The skills and experiences of role teacher to facilitate the process of argumentation is also a prominent aspect. It is also influenced by the students' response which are actually as representative of knowledge that students have. The training to always claiming followed with the reasoning and evidence, is also important. And the various learning experiences that provided for students. All factors are involved together in the process of argumentation. Therefore, it is a must to apply all aspects in the process of learning simultaneously.

When teacher addresses to only adopt model or method of learning to improve argumentative skills of students, then it will come with the fact that students have experiences to deepen their concepts, but they cannot argue correctly. Thus, teacher has to thickened the model with assessment that will drill students to do routine argumentation. It can be also added the argumentative dialog, such as Socrates dialog to help students do correct argumentation, during the learning process.

The learning design that role teachers used in these action research were constructed based on the principles that students have to be provided with various experiences of learning. Role teachers, teachers, and researchers worked together to design appropriate lesson design which were concentrating on how students construct the knowledge. Therefore, the design was totally different with what have been routinely used by teachers. However, those lesson plans still follow the standard that determined in The Curriculum 2013 of Indonesian schools, and also met the time allocation of each topic of learning.

4. Conclusion

The process of argumentation of three action research which were conducted in different schools showed that a good action is the one that focus on training the students to do routine argumentative dialog by always posing argumentative questions and answer with clear claiming followed by reasoning and evidence. The process has absolutely influenced by the skill of teacher to ask trigger questions, and to keep the dialog sequences on the track of argumentation process. Formative Assessments which provides test with answer have to follow the sequence of argumentation will help students to be familiar with the argumentative skills.

The three action research had significantly changed the habit of teachers to directly answer the open-ended questions, and make corrections of students' answer. This changed practices have a good impact on how students learn how to argue. However, there is no significant impact of working experiences of role teacher in the process of argumentation.

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