Improving the argumentative skills of high school students through teacher's questioning techniques and argumentative assessment

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Abstract. This research aims to know how students' argumentative skills improved by applying teacher's questioning techniques and argumentative assessment through collaborative action research between college student who did teaching practicum, biology teacher as tutor teacher, and lecturers. The action research was done in three cycles involving one class consisted of 36 eleventh graders. Lesson plans were developed collaboratively, and teaching practices were by the student teacher. In the reflective phase prior to the first cycle, learning processes were dominated by the teacher, hence students did not have sufficient opportunity to argue. Students were divided into two, 14 students were grouped as low achievement (LA) and 22 students were the high achievement (HA). Teacher questions and students' responses were furtherly coded and interpreted following the validated rubric of level of argumentation. A divergent essay as an argumentative assessment was also tested to students at the end of each cycle. At the end of the third cycle, HA and LA students showed a significant change in argumentative skills responded the teacher's questions. However, only four LA students who actively argued. Students from HA groups also showed the improvement on the level of argumentation, where they move from level 1 to 3.

1. Introduction
Argumentation is a systematic exploration activity of theoretical confrontation through the coordination between the evidences that describes the results of empirical observations or experimental results about natural phenomena [1]. Argumentation is an important practice in science, scientists are developing knowledge by testing scientific claims, considering evidences and assessing alternative explanations [2]. Argumentation is the process of collecting the various components needed to build an argument [3]. The indicator for component of argument from Toulmin argument (1958) have been reduced by Krajcik & McNeill [4] to fit the student's abilities and consisted by four components of argumentation: claim, evidence, reasoning, and rebuttal. Claim is an idea, a conclusion, hypothesis, or views about events or phenomena [5]. Evidence is the proof or evidence for the claim. Reasoning is the reason to connect evidence with the claim. Rebuttal is alternative answer to reject the unappropriated claim [4].

Based on the results of preliminary observations, the students looked passive at learning process, the majority of the students were just paying attention to the lecture by the teacher and only several students took the note. When the teacher asked a question, the students gave simultaneous and short answers without evidence or reasons. The students were not used to express their opinions about the material.
Factors that affecting the lack of students' argumentation skills were the habits of the teachers who still dominate the learning processes. The questions given by the teacher to students do not encourage students to express their opinions. The teacher's evaluation also does not encourage students to argue. Teachers were used to asking students to memorize the concepts on the material that considered important rather than discussed the material being studied.

Argumentation in learning process could support students the cognitive, metacognitive processes, and reasoning [6]. Student's arguments can be trained through teachers’ questions in learning progress. Of the eight teaching basic skills, questioning skills were skills that dominate in learning because the questions can support other basic skills [7]. Through the skills of asking questions, the teacher could detect obstacles that faced by the students in developing their thinking skills to thinking and could improve the learning process. Providing questions when learning process was important because to preserve the students' attention and involve the students in the learning process [8]. Questions can direct the learning process, build the students' knowledge, and improve the quality of discourse and communication in the classroom. Questions also used to evaluate and check the students' understanding and increase motivation and interest of the students in learning process by sparking students' curiosity [9].

Divergent questions can lead to different answers from students. Divergent questions encourage the students to analyse, synthesize, or evaluate their knowledge and then predict different outcomes. The divergent questions also can stimulate students' imaginative and creative thinking or investigate the cause and effect relationship, leading to wider investigation [10]. Questions can be deliberately made to optimize the learning process. Teachers' should make effective questions, such as qualitative and analytical questions. Qualitative questions were superior to quantitative ones because they can generate discussion among the student about the concepts, theories, and general relationships of the learning materials. Analytical questions require student to make decision and lead to better discussion than the questions that only need the students to recall their memory [11].

Training for the students' argumentation skill can also be conducted through the teacher's assessment questions to the students. All this time the assessments were more emphasizing to students to memorize the concepts rather than associate the concepts with the phenomena or give the right reasons for their answers. Good assessment questions to train the students' argumentation skill can be done using Argumentative Assessment by Standpoint, Scaffolding, and Coding. The model begins with the standpoint, the controversial question related to the material being discussed were designed as a starting point for the development of argumentation skills [12].

2. Methods
This research was a Classroom Action Research implemented to improve students' argumentation abilities. The study was conducted during September 2016 to February 2017, on the topic of Musculoskeletal System and Excretory System. The population of the research is the eleventh graders in one of the senior high schools in Boyolali, Central Java Province in Indonesia. Sampling was selected purposively, hence one class was selected as the research subject. The selected class were comprised of 36 students (22 girls and 14 boys) with mixed academic achievement and abilities.

The research was a collaborative research among the tutor teacher, lecturers, and college students. The one who teaches during the research was the college student. The pre-cycle phase was done when the college student was undergone an Internship Teacher Preparation Program at the school. The college student, along with the lecturers and the tutor teacher formulated the actions that was applied when research took place. The steps of the research were compiled according to cyclic model from Kemmis, McTaggart, & Nixon [13] that has stages of: reflecting, planning, putting plans into action, observing the process, and reflecting and reformulating the plan for next action. These steps then become personal reflections that make up the spiral cycle.

The research began with the grouping of the students based on their quaternary (Mid-Semester) exam results. Students grouping based on the score of the Minimum Criteria for Student Competencies (MCSC) -the benchmarks of students' competencies- formulated by the school. Students with the scores
below the MCSC value were grouped as Low Achievement (LA) and the students with the scores above the MCSC value were grouped as High Achievement (HA). The categorizations made to track the development of the students in each group after implementing the action.

The planning stage includes the activity of preparing the learning instrument, i.e. the lesson plans, learning media, student worksheet, argumentative assessment, rubrics for syntax implementation, script for teacher questions, rubrics for student responses, and rubric for teacher and students interview. The implementation phase was done by applying the learning model of Discovery Learning combined with the teacher's scenario of questioning technique during the learning process, and the argumentative assessment at the end of learning. The data were collected by observation based on the rubrics that have been prior validated. The data analysis phase was done by analysing the patterns of teacher questions with the questioning rubrics as a coding and analysing the students' answers using the rubrics of argumentation level according to Osborne et al. [3].

Question scenario prepared as question circle. Question circle is a strategy that directs students from common responses into deeper topic discussions. The strategy would bring the students to three different domains; the subject matter being discussed, personal responses, and external reality. Subject matters that include factual, conceptual, procedural knowledge was gained during the learning process. The personal responses were the reaction of learners based on perceptions and experiences that related to the subject matter. External reality was the relation of subject matter with society and other disciplines [14]. The result of teacher questions and students' responses would be analysed by using the coding system to understand the questions pattern and students' responses to the question. While coding is a system that simplified the process of assessment and analysis of the quality of argumentation [15]. The coding system allowed for direct recording of observation and benefits for the researchers in terms of time and analysis [16].

Argumentative assessment was given as an essay with divergent questions. An essay question with divergent questions was expected could enable the students to develop an opinion on the answers. Divergent questions are the open-ended questions, which can have many responses, from which the conclusions can be drawn and can develop multi-dimensional thinking skills [17]. Argumentative assessment is expected to encourage the students to provide answers broadly, not pigeonholed to the material being studied alone but also connect it with daily life problems so it can bring up argumentation. The results of assessment on the students' argumentation will be analysed with the rubrics of level of argumentation according to Osborne et al. [3]. The student argumentation level would be scored as to measure student's performance. The scoring for each level of the argument depends on the number of questions given in the argumentative assessment. Level 1 got the lowest score and level 5 got the highest score. The highest score was 100.

3. Result and Discussion
Based on the initial grouping, there were 14 students who categorized as the LA group and 22 students categorized as the HA group. Students belonging to the LA group were student No. 8, 10, 11, 14, 16, 17, 20, 22, 24, 28, 30, 32, 33, and 34. Students belonging to the HA group were student No. 1, 2, 3, 4, 5, 6, 7, 9, 12, 13, 15, 18, 19, 21, 23, 25, 27, 29, 31, 35, and 36.

The reflecting was taken during the pre-cycle from September to October 2016 on the topics of the musculoskeletal system. During the pre-cycle, learning processes were done by direct lectures and discussions. The teacher explained the topic while displaying PowerPoint slides and the students listened, and some of the students took notes.

Based on the teacher's reflective diary, students were very passive during the pre-cycle learning process. Students still give a brief unison answer, and the teacher did not provide the follow-up questions. The arguments presented by the students were only claims. Students could not answer with data or facts (evidence) and give reasoning. Based on the argumentative assessment provided by teachers in the pre-cycle, many of the students were still at the lowest argumentation level.

Teacher applied the learning model of discovery learning combined with the questioning scenarios and argumentative assessment in the first cycle. Learning in the first cycle was focused on the excretory
system of human on the part of skin (sweating process). The questioning scenarios were included in the lesson plan. The questioning scenarios were aimed to direct the students to build concepts knowledge and engage students to give arguments during the learning process. Argumentative assessment also has been prepared to assess students' level of argumentation in writing.

The result of observation of the students' argumentation ability showed gradual changes and improvements. During the first cycle, the level of the students' argumentation can be see through the students' dialogues and answers. An example of dialogs in the first cycle were presented in Table 1.

**Table 1. Example of Student's Dialogues at the Discussion and Presentation of the First Cycle**

| Learning Process | Subjects | Dialogues | Coding |
|------------------|----------|-----------|--------|
| Apperception and motivation | Teacher | What do you think about the sweat? | Q1-1 |
| | S28* | The fluid excreted by the body | A1-4 |
| | S7 | Product of metabolism | A1-2 |
| | Teacher | What do you think about the characteristics of the sweat? | Q2-1 |
| | S36 | The sweat was excreted to maintain body moisture | A1-2 |
| | S1 | Usually the sweat was smelly and salty | A1-4 |
| | S7 | Sweat usually considered as one of the mechanism to reduce body fat | A1-2 |
| | S29 | The sweat was produced when we do heavy exercises | A1-4 |
| | S9 | Sweat usually causes yellow stain on the white shirt | A1-4 |
| Hypothesis testing | Teacher | Why can you connect it with alum powder? | Q4-1 |
| | S1 | Because I've read that before there was a deodorant, people use white alum powder to remove body odor and it seemed to be more safety than deodorant | A4-2 |
| | Teacher | Are there any opinions or responses to your friends' questions and statements? | Q5-1 |
| | S22 | Yes, ma'am. I've read on the internet if alum can prevent body odour, but it does not cause the blackened armpits and yellow stains on the clothes. | A4-2 |
| | S8 | Yes ma'am, I do not wear deodorant and no yellow stain on my shirt | A4-1 |
| | Teacher | After you wear the uniform, what do you do to avoid the yellow stain? | Q1-6 |
| | S8 | Wash it immediately | A1-5 |

*S means Students. Number follows S is a student number

Based on the rubrics of teacher questions, in the first cycle, the teacher presented Q1-1 questions on apperception stage, which is the questions of general definition or students' general views of sweat to check the prior knowledge of students. Q2-1 questions were delivered by the teacher to motivate students by asking for the further explanation about one aspect of the sweat. Teachers should be able to develop questions about other aspects of sweat. The Q4-1 type questions were delivered by the teacher on the syntax of hypothesis testing, asking the students to present general facts that contradictive to the use of alum powder as the substitute for deodorant. Q5-1 type questions were also delivered by the teacher on hypothesis testing, asking whether students were agreed or disagree with their peers' opinions. In the first cycle, the students discussed that sweat caused yellow stains on the shirt. Students also discussed whether the use of alum was safer than deodorant. The answers presented by the students also varied. Many students who answered with type A1-4 mentioned the claim based on facts related to the topic. Type A1-2 answers were also submitted students as claims based on the theory. Students could also deliver the type A4-1 answer (deliver the contradictive common facts), type A4-2 answer (deliver the
contradictive theories), type A1-5 answer (deliver the claim as the procedure). Students whose involved in the dialogue were 8 students, 2 of them were LA students (S8 and S28). The answers submitted by the students in the first cycle were still considered less diverse and teacher questions could be developed to encourage the students to answer more divergently. Based on the students' activities, it has shown a good improvement in argumentation activity compared to pre-cycle, but based on the argumentative assessment result, the students have shown not yet optimal improvement of the argumentation level from the pre-cycle because their answers were not diverse. Teachers’ questioning scenarios were also considered not yet optimal so that there is a need for changes and improvement for the next learning cycle.

The second cycle was implemented on the topic of the excretory system on the sub chapter of urine excretion. Teacher applied divergent questions in the beginning of learning process to attract the students to think about urine as the product of excretion. Students expressed their opinions about urine. From the students’ opinions about the characteristics of urine, factors that affect urine formation, the process of urine formation and diseases related to the kidneys, the teacher directed the students to formulate the research problems and hypotheses. The initial process of learning went smoothly and the students looked enthusiastic. Observers also noted that the students hesitated to interact with their peers.

The results of the analysis of the teacher's question showed the Q1-3 question (asking the concept of urine) was delivered during the apperception stage. Q1-4 questions (asking the facts about how the colour of urine) was delivered during the syntax of motivation. Type Q3-2 questions delivered to attract the students to explain why the colour of the urines was different. Q5-1 questions were delivered by the teacher during the hypothesis testing to request approval or rejection from students. Students could express their opinions on various levels. Type A1-4 (deliver the claim as facts) answers were still dominated as the pattern of student answers. Type A1-2 answers were also given by students to submit the claims based on the theories. There is also an A3-2 answer which delivers the cause and effect proof for the claim. Students could also express the type A4-5 answers about procedures contradictive to commonly used procedures. Students could also respond to teacher questions with A5-1 answers. It showed how much concept understanding and information received by the students, so the students could provide opinions according to their understandings. Based on the dialogues, there were 11 students involved in the learning dialogue and 3 of them were LA students (S17, S28, and S30). S17 answered twice, and S28 could answer 3 times. The answers presented by S28 included the answers that have a good level of argumentation and fit logical concepts and reasons even the student was from LA group. Research continues to optimize students' abilities.

The third cycle was implemented on the topic of the excretory system with the sub chapter of the Liver and Lung. The teacher combined these two sub chapters because the students have studied the topic on the digestive system and the respiratory system. Learning activities run smoothly might be because students felt they had learned about the material.

In the third cycle, based on the results of the teacher's questions analysis showed that there are some improvements of quality of the questions delivered by the teacher. The teacher asked Q1-4 questions at the beginning of the lesson (ask about the facts about jaundice/ icterus neonatal), followed by the Q3-2 question to made connection of cause and effect. Q1-4 questions were re-submitted (ask for facts about shortness of breath), followed by the Q3-2 question (ask for the cause of shortness of breath). Q5-1 questions were presented in hypothesis testing to ask students' opinions in general and Q5-2 was used to ask students opinions in detail.

Based on the analysis of the students' answers, students presented answers with varying levels of argumentation. Students could answer with the A1-4 answer (deliver a claim as facts). A2-1 answers were used by students to explain one aspect of the topic. The A3-2 answer was presented by students to make the connection of cause and effect. Type A3-3 answer was presented by students to prove their claims with scientific evidence. Meanwhile, A4-5 answer was submitted by the students to express the opinion toward other procedures to strengthen their claims.

There were 14 students involved in the dialogue in the third cycle, and four of them were LA students (S11, S16, S28, and S32). It also showed that there were more students involved in expressing the
opinion during the learning process. Students of LA group also intensified their participation in the learning process. It showed the changes and improvements in students’ argumentation abilities because they could answer with various types of argumentation level.

Based on the argumentative assessment data obtained from each cycle, there were improvements in the level of students’ argumentation. Changes and improvement in students’ argumentation skills of LA and HA groups were presented in Figure 1 and Figure 2. Figure 1 showed the diversity of argumentation scores of each cycle obtained by the LA students. S8, S10, S17, S20, S28 experienced constant changes of argumentation scores. While S11, S14, S24, S32, S33, S34 underwent fluctuations in argumentation scores, and S6, S22, S30 were gradually improved.

The argumentative assessment results were linked to the dialogues that occurred on each cycle. S28 was the most prominent in the dialogues, although, from the LA group, he actively participated in the learning process. S28 could propose answers to the arguments in each cycle and showed an argumentative assessment score with the progress that able to match the students of HA group. It showed that there were students who initially have low scores had been able to actively develop the argumentation skill after implementation of the learning model. Based on the comparison of each cycle showed that only 16 students who have not reached level 3. Overall, the LA students have been able to reach level 3 of argumentation.

![Figure 1. Comparative diagram of changes of LA group students' argumentation level, in pre-cycle, the first, second, and third cycle](image)

Figure 2 showed the results of the argumentative assessment of the HA students in each cycle. Students have varying argument scores at the pre-cycle and showed various improvements for each cycle. S1, S2, S3, S5, S9, S12, S13, S15, S18, S19, S21, S23, S31, and S35 experienced an increase in argumentation scores from the pre-cycle. S4 experienced a gradual improvement of the argumentation score. S6, S25, S26, S27, and S36 experienced fluctuations in argumentation scores. Based on the comparison of the results of the argumentative assessment of each cycle shows all of the students of the HA group managed to show changes and improvement in the level of argumentation, reaching level 3. Overall, the students have been able to present the answers along with the evidence and reasoning or at level 3 measured by the framework of the level of argumentation based on Osborne et al. [3]. At the end of third cycle, the students have shown improvement of argumentation skills compared to pre-cycle. It is shown from the observation of each cycle showed that the students have been able to provide claim, evidence, and reasoning with the help of the teacher. The students’ argument scores have been improved.

The results of the research proved that the teacher's questioning scenario and argumentative assessment can improve students’ argumentation skill. Students who at initial stage only able to submit claims at pre-cycle could express argumentation with the data (evidence) and reasoning after the
implementation of this action. Application of the teacher's questioning techniques in learning process encourages the students to accustomed to arguing during the learning process. The questioning techniques also gradually improved from started with general questions to detailed-specific questions.

![Figure 2. Comparative Diagram of Changes of HA Group Students' Argumentation Level, in Pre-cycle, the First, Second, and Third Cycle](image)

The questioning also helped the students to build the conceptual knowledge during the learning. Nussbaum, Sinatra, & Poliquin [18] states that the instruction to deliver arguments can help the students change their conceptions in learning. Acar [19] found that the development of argumentation skills was related to the development of conceptual knowledge. From his research, the LA students also performed higher in argumentative assessment score. The improvement shows that arguments could develop students’ conceptual knowledge. Ramli et al. [20] argued that teacher's skills and scaffolding are also the successful of argumentation process in the classroom. Teacher's pedagogical skills, such as skills to ask, answer and respond to the students' statements and questions are factors that bring a significant impact to students' argumentation process.

Argumentative assessments could also train students to give proper evidence and reasoning in answering the questions. Questions for the assessment were not only emphasizing the memorization of concept but also provoke students to think more broadly. Students can give opinions based on facts, theories, and concepts to support the answers. Students were not pigeonholed to develop their knowledge just from books alone but can connect with their experiences backed with scientific evidence and logical reasoning to generate argumentation. The results showed that the students experience changes and improvements of oral and written argumentation skill. According to Clark [15] the use of open-ended assessment could help students to explore their knowledge by providing feedback in the form of arguments.

In the learning process, the argumentation of student might be influenced by his or her peer. In the mix ability class, HA students are supposed to have a better performance than the low ones [21]. However, LA students show increasing performance is not exactly because of LA students' effort themselves. They might be argued better due to the interaction between HA and LA students, and also teacher's instructions and guidance during the learning process. Therefore, there should be a detail research in the future to detect how big the impact of HA to LA students in arguing.

4. Conclusion

The results of the present research are the are changes and improvements in students' argumentation skill after the application of teacher's questioning techniques and argumentative assessment. Students' argument that originally just as claims have been optimized under the rubric of the level of argumentation. Students in the LA and HA groups showed the change of argument up to higher level. Students, generally have achieved level 3 of argumentation, which able to show evidence and reasoning to the arguments.
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