

Enhancing Students' Argumentation Skills Using an Argument Driven Inquiry-Based Module

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ABSTRACT

Argumentation skills as a form of communication has function to externalize ideas through scientific discourse is a very important in learning of science. As an integral part of the science, argumentation skills should be included as a component of learning science. The purpose of this study is to determine the effectiveness of argument driven inquiry-based module in enhancing the students' argumentation skills. This study was conducted at one of the State Senior High School in Surakarta academic year 2016/2017. The pre-test and posttest research design with treatment and control class groups were used in the study. While the treatment group taught by using module based on argument-driven inquiry, the control group was taught by a module that commonly used at school. As the study concluded, using argument driven inquiry-based module in the learning process is effective to enhance the quality of students' argumentation skills.

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1. INTRODUCTION

The increasingly rapid development of science and technology in 21st century impacts on various aspects of life, including in education aspect [1]. Education plays an important role in improving human resource quality. Education is required to prepare and to produce high-quality human resource in order to process information well and correctly [2]. High quality human resource should have necessary skill or competency in 21st century. One of skills necessary in dealing with digital era in 21st century is communication skill [3]. Communication skill is a competency in delivering message (ideas, thoughts) from one party to another to allow interdependency between both of them [4]. The important part of communication skill in science field is argumentation skill [5].

Argumentation skill is an individual's skill of organizing a statement accompanied with evidence and logical reason aiming to justify belief, attitude or value, to maintain it, and to influence others [6]. Argumentation, according to Simon, Erduran, & Osborne [7] is a process of collecting a variety of components necessary to build an argument. The components of argument, according to Toulmin in Chan & Esther [8], consist of claim, evidence, warrant, backing, qualifier, and rebuttal. The components of argumentation, according to Toulmin, are adjusted by McNeill & Krajcik [9] with the students' ability of understanding the definition of individual components, and yield 4 components: claim, evidence, reasoning, and rebuttal. Claim is an idea, a conclusion, hypothesis, or opinion on an event or phenomenon [10]. Evidence is a scientific data to support claim [11]. Reasoning is a reason given to connect evidence to claim. Rebuttal is an alternative answer to refuse claim as claim given is considered as less appropriate [9].

Argumentation skills is an important requirement that must be mastered science because science learning 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 [12] stated that learning science allows the discussion about the facts obtained and the theory prevailing in the nature that argument is very important in constructing science knowledge. As an integral part of the science, argumentation skills should be integrated as a component of learning science. Socio-cultural view emphasizes on the social interaction in the process of learning and thinking, the ability of thinking critically honed through discussion, argument and experience exchange among students [13], [14]. This requires the argumentation skill to be taught in a structured learning science, and implemented in the science learning activities as an argument in science has a unique character distinguishing it from other disciplines. In the perspective of social activity, argumentation focuses on the interaction between individuals where someone tries to expresses statement or particular matter. What matters is how we can convince others that his opinions are acceptable reason, evidenced by the relevant proof and reason, because it is the skill of looking at a multi-perspective problem by using as much as possible supporting evidence. This is usually an obstacle for students and teachers of science. In addition, argumentation skill can help improve scientific knowledge because through argumentation process, students can construct the answer appropriately to the concept of science [15]. Considering the explanation above, argumentation skill is important to develop in learning process.

The fact shows that learning in Indonesia has not facilitated the students yet to develop their argumentation skill. The learning process is still teacher-centered. It leads to a less conducive learning circumstance for the students to develop their argumentation skill. When students are put on the position of exchanging thoughts or ideas rarely, their argumentation skill will be poor [16]. Tama's [17] and Pritasari's [18] studies mentioned that argumentation skill of Senior High School students in Surakarta still in the low category. It can be seen from the students' answer, there is no strong foundation when they have discussion. The answers of them which given was still in form of sttement without followed with supporting evidence and reasons so that the score of individual argumentation skill aspect is still low.

Students' problem in having low argumentation skill also occurs in State Senior High Schools in Surakarta. The fact found in early observation that showed during the learning process only a few students express their opinions related to the materials. When the teacher asks, the students, their answers were still in a simple statement without any support of evidence and reason. Discussion and interaction activities between the students and teachers are less intensive. The results indicated that the students were not been trained to argue yet. The result of observation was conducted based on the measurement of argumentation skill. According to McNeill & Kracjik [9], they explained that the percentage of students' argumentation skill aspect as follows: claim 44.08 %; evidence 26.88 %; reason 20.43 %; and rebuttal 0%. The mean of students' argumentation skill is 22.84%. Based on the results obtained, the ability of the students' argument skill is still low.

The results of need analysis conducted in one of State Senior High Schools in Surakarta Indonesia indicated that low school achievement of competence in biology materials with an average score, it was only 78.84%. Based on the data, namely the result of national exam, they showed that the excretory system matter got low score and had the decrease in its percentage for three consecutive years from 2013 to 2015: 56.84% in 2013; 66.31 % in 2014; and only 49.59% in 2015. The result of argumentation skill analysis on module and book which commonly used at school showed that the score was still low. The claim aspect got score of 30.0% in the first book and 22.0% in the second book; the evidence aspect reached score of 13.0% in first book and 12.0% in the second book; the reasoning aspect had score of 16.0% in the first book and 15.0% in the second book; and rebuttal aspect got score of 0.00% in the first book and 0.00% in the second book. Considering the result of analysis, it can be concluded that book and module used in one of Public Senior High Schools in Surakarta does not used argumentation skill optimally yet.

An alternative way to enhance students' argumentation skill optimally is using suitable learning materials such as a module. Module is one type of teaching materials presented systematically, so that the user can learn with or without a facilitator or teacher. Module is a learning material that can encourage and give students a chance to study independently and to study appropriately according to students' ability [19]. Septiani, et al. [20] stated that the use of module leads the students to learn individually, meaning that they could adjust the speed of learning to their ability. Setyawan [21] stated that the use of scientifically-based module in learning would be effective at improving students' critical thinking skills. The learning process using module allows the students with a high ability of learning to complete a basic competence faster than other students. In addition, through modules, students can measure the level of their mastery of learning materials.

The optimization of module development to empower the students' argumentation skills can be done by integrating the learning model that can accommodate the emergence of argumentation aspects in the module. One of alternative learning models which appropriate to integrate into module is Argument-Driven

Inquiry (ADI) learning model. This strategy was developed by Sampson & Gleim [22] as an integrated learning unit to encourage the students to participate in an interdisciplinary work, so that it might improve the students' understanding on important and practical concepts in Biology [22]. ADI is a laboratory-based learning which can improve the students' knowledge and skill by participating in several scientific argumentation through reading and writing activities [23]. ADI learning strategy consists of a set of activities and it is expected to be developed to the students' in active participation in an argumentation discourse and it is expected to improve the students' argumentation quality.

The efforts to increase the active participation of students in the learning process inspire the researchers to develop a module based on argument-driven inquiry for excretory system subject. The module which developed was expected to support the learning process, to guide the students in doing their activities independently through structured activities in the module and to increase the argumentation skill of students according to the 21st century's demands.

2. RESEARCH METHOD

The study research involved two (1th grade) classes consisting of 31 students in each class. The classes were selected by using a simple random sampling method. The equivalence of two groups was tested via a number of instruments. These were achievement test, probing questions and logical thinking test. Kolmogorov-Smirnov test results indicated that there were no statistical differences between the two classes in terms of the scores taken from each test/scales aforementioned. Therefore, the two groups of students were accepted as equivalent.

The research design used was *pretest and posttest non-equivalent control group design*. The observation technique was conducted to find out the students' argumentation skill in experimental and control class before and after learning using module in excretion system material. The research design is presented in Table 1.

Table 1. Research Design

Class Group	Treatment		
Experiment (N = 31)	O ₁	X ₁	O ₂
Control (N = 31)	O ₁	X ₂	O ₂

O₁ : Pretest (Observation on argumentation was given skill before treatment)

O₂ : Posttest (Observation on argumentation skill was given after treatment)

X₁ : Learning model using an argument-driven inquiry-based module

X₂ : Learning model using module which commonly used at school

Considering the Table 1 above, it can be seen that each of class consists of 31 students. The experiment class was taught using argument-driven inquiry based-module developed by author, while the control class was taught using existing modul at school. The module based on argument-driven inquiry was conducted by giving activities using argument-driven inquiry syntax by Sampson and Gleim [22]. There are identification of the task, the generation of data, the production of a tentative argument, the interactive argumentation session, the creation of a written investigation report, double-blind peer review, the revision process, a reflective discussion. Validity of module based on argument-driven inquiry on the excretory matter to increase cognitive learning outcomes which were valid based on the average score of validaion by experts. Module based on argument-driven inquiry had score 90% by an expert of matter; 97.5% by an expert of module development; 100% by linguist; 78.25% by an expert of learning device; 88.75% by education practitioners; and 90% by students. Therefore, module based on argument-driven inquiry on excretory system matter, it was appropriate to increase cognitive learning outcomes which was interpreted as valid and it was implemented to the treatment class group. This research was conducted 5 weeks with a summary of activities in Table 2 below.

Table 2. The Summary of Research Activities

Week	Research Activity
1	Pretest (Observation on argumentation skill before treatment)
2 - 4	Treatment (learning using an argument-driven inquiry-based module in experiment class and learning using module commonly provided at school in control class with the same material)
5	Posttest (Observation on argumentation skill after treatment)

Table 2 above shows the condition before treatment, all of students' statements were observed and recorded during learning process to find out their argumentation skill in both experiment and control classes. After observation, both classes were given treatment in 3 weeks. After the treatment, all of students' statements were observed and recorded to find out the change of students' argumentation skill. All of statements were analyzed using the argumentation skill assessment rubric which developed by McNeill & Krajcik [9], as shown in Table 3 below.

Table 3. The Argumentation Skill Assessment Rubric Developed by McNeill & Krajcik (2011)

Argumentation skills aspect	Level		
	0	1	2
Claim It is a statement that is given as a response for a question asked or a conclusion	There is no claim or a false claim	There is a true but incomplete/ missing claim	There is a true, complete and accurate claim
Evidence It is scientific fact that supports the claim. The data must be appropriate and sufficient to support the claim	Evidence is not provided or it is provided but it doesn't support the claim	Appropriate but insufficient evidence is provided. It may contain some inaccurate evidence	Appropriate and sufficient evidence is provided to support the claim
Reasoning It is a justification that allows evidence to be associated with the claim	Reason is not provided or a judgment is made that does not associate the claim with the evidence	A judgment is made that associate the claim with the evidence. Evidence is repeated and / or it includes some more scientific principles which are insufficient.	It is a judgment that associate the claim and the evidence. It contains appropriate and sufficient scientific principles
Rebuttals Alternative explanations are given and explained. Counter-evidence and reasoning are provided to show why alternative explanations are not appropriate.	Available alternative explanation is not given. Rebuttal is not provided or a false rebuttal is given.	Alternative explanations are given. Insufficient counter-evidence and reasoning which are proper but not sufficient to build a rebuttal are given	Alternative explanations are given. Sufficient counter-evidence and reasoning which are proper and sufficient to build a rebuttal are given

The arguments as data which obtained from the observation and voice recording taken during the practices then they were analyzed according to the descriptive analysis. In descriptive analysis, the aim is to present the finding to the reader in an organized and interpreted way [24]. For this reason, the students' arguments have been examined according to the rubric (see Table 3) developed by McNeill & Krajcik [9]. Arguments were coded in this direction by claim, evidence, reasoning and rebuttal. Claim, evidence, reasoning and rebuttal were scored according to the level of their situation. Scoring was done as following; 0 point was given to Level 0, 1 points to Level 1, and 2 points to Level 2. Then averages of the scores obtained from these components were calculated. In the process of coding the arguments, the opinions of a researcher who had previously worked on this subject were frequently referred too.

The difference of pre and post test scores between control and experimental class groups had been analyzed. During the data analysis, parametric tests were used because the normality assumptions were fulfilled. In data analysis, potential difference between control and experimental class groups before and after the module implementation in the learning process was assessed by using Independent Samples T-Test. After the learning process using module which commonly used at school and argument driven inquiry-based module, in both control and experimental class groups, the difference of pre and post test scores was analyzed using its N-gain. The criteria used in the N-gain value, according to Hake [25], were presented in Table 4 below.

Table 4. The Criteria of Gain Index and Its Interpretation

N-Gain	Interpretation
$g < 0,3$	Low
$0,7 > g \geq 0,3$	Middle
$g \geq 0,7$	High

3. RESULTS AND ANALYSIS

Module is developed by using eight steps of argument-driven inquiry model syntax that was integrated with four aspects of argumentation skill. The module itself is divided into three chapters of the excretory system subject. There are lungs as excretory organ, skin as excretory organ, kidney and liver as excretory organ.

The result of analysis on the argumentation skill aspect scores arising based on the result of observation, and it was presented in the following Table.

Table 5. The Result of Argumentation Skill Aspect Scores

Aspects	Control Class		Experimental Class	
	Pretest	Posttest	Pretest	Posttest
<i>Claim</i>	80%	83%	80%	88%
<i>Evidence</i>	9%	12%	9%	26%
<i>Reasoning</i>	32%	34%	39%	58%
<i>Rebuttals</i>	2%	5%	2%	19%
Mean	31%	34%	33%	48%

Table 5 above shows that there is a significant difference of pretest scores in term of argumentation skill between experiment and control classes. The mean of pretest score of control class was 31%, including: 80% for claim, 9% for evidence, 32% for reasoning, and 2% for rebuttal aspects. Meanwhile, that of experiment class was 33%, including: 80% for claim, 9% for evidence, 39% for reasoning, and 2% for rebuttal aspects. The mean posttest score of argumentation skill in experiment class is higher than that in control class. The mean of posttest score of experiment class was 48% including: 88% for claim, 26% for evidence, 58% for reasoning, and 19% for rebuttal aspects, while that of control class was 34%, including: 83% for claim, 12% for evidence, 34% for reasoning, and 5% for rebuttal aspects

The descriptive analysis results of pre-test and post test scores in treatment and control class groups are presented in Table 6 below.

Table 6. The Scores of Pretest and Posttest in the Treatment and Control Class Groups

Class Group	Scores	Minimum Score	Maximum Score	Mean	N-gain		
					Min	Max	Average
Eksperimental	Pretest	6	15	2.35	0	0.34	0.85
	Posttest	10	44	10.41			
Control	Pretest	4	11	0.74	0	0.16	0.32
	Posttest	8	16	3.93			

Based on Table 1, it can be seen that the average score of pre-test in the experimental class and control class was not much different, where the pretest score average of each class were respectively 2.35 and 0.74. The results of the post-test as presented in Table 5, it could be seen that the average score of posttest in experimental class was higher than that in control class, where the average of post test score of experimental class was 10.41 with N-gain score was as much as 0.85 (middle criteria) and the average of posttest score of control class was 3.93 with N-gain score was 0.32 (low criteria).

The argument in its implementation as driven inquiry-based module in the excretion system subject had increased the students' argumentation skill significantly and effectively. The effectiveness of module can be seen from the increase in the scores of posttest and the argumentation skill after the learning process using argument driven inquiry-based module. The increase of argumentation skills posttest was calculated by the score of the N-gain. The result of its analysis was presented in Table 5. It showed that the mean of N-gain in term of argumentation skill in experimental class was higher than the control class, 0.85 could said and high category.

Module is a learning material that can encourage and give students a chance to study independently and to study appropriately according to their ability [19]. Setyosari [26] said the advantages of using module in learning are students' motivation can be increased, students' task can be identified quickly, students' learning outcomes can be adjusted with students' ability, and it is more effective and efficient in learning. Learning using the module is more effective than conventional learning, because through using the module students can learn independently, so that students can develop the learning steps, needs, and ability affecting the students' learning outcomes in the class which taught using the module as a student teaching material [27]. Howard & Miskowski [28] added that 79% students were helped to understand Biology Cell topic using

Inquiry Module-based Laboratory. Howard & Miskowski [28] also mentioned that students' performance after using the module was better than before. Hatzikraniotis et al. [29] reported that there was an increase of scores from the pretest to the posttest after using an inquiry module. Using a module in learning as compared to the traditional method of using a textbook is meant to increase the active learning and improve students' critical thinking, as well as problem solving skills. It also gives the teacher opportunity to conduct informative assessment in the classroom. Standardized textbooks have their own styles, and their contents, depth of coverage of materials, and organization, they may affect the teaching and learning environment. Thus, the use of a module presents a more flexible learning environment for both teachers and students.

The results of the activity in the module, presented in Table 5, it shows that the activities the students did using syntax of argument with driven inquiry can practice the students' argumentation skill aspects. The results during a research which supported by Sampson, et al. [30] showed that the application of ADI had a positive impact on the learning process in the classroom, especially in creating a conducive atmosphere for the students to argue. The students had better disciplinary engagement and produced better arguments after the intervention. The interaction within the group pushed the students to submit opinions more freely without fear. ADI learning model practices students to construct explanation or knowledge and share ideas in small groups in class discussion, thereby creating a class circumstance providing "process" culture in science learning [23]. It is in line with Zohar and Nemet [31], Myers [32], Okumus and Unal [14], Demircioglu and Ucar [33], Hasnunidah, et al. [34], Farida and Gusniarti [35], and Ginanjar, et al. [36] concluding that the learning process which involving ADI model activities can improve the students' argumentation skill. Walker, et al. [37] added that the activities in ADI model can improve the students' ability significantly in giving evidence and reasoning to support claim, thereby creating a good and correct argumentation.

The argument driven inquiry-based module used in the learning process can enhance students' argumentation skills because it presents the activities structured in the form of some experiment and observation using the syntax of argument in driven inquiry, in which every aspect of argument driven inquiry is integrated into aspects of argumentation skill. The first stage of ADI model is task identification containing problem or phenomenon presented in the form of discourse and picture. Based on the discourse and picture provided, the students are directed to identify the problem so that they can formulate problem and develop hypotheses or temporary answer to the problem statement. The syntax of task identification is integrated into claim aspect in the form of hypothesis formulation as temporary answer to the problem later proved for its truth in data collection and analysis stage [22]. The research data showed that the students' achievement in the pretest and posttest aspects was the highest compared to the achievement of claim aspects of the evidence, reasoning, and rebuttals. The results were supported by the results of the research Cho and Jonassen [38] which states that students are more focused in making a claim (statement) because it is a basic part of the solution to a problem. Kaya, Erduran, & Cetin [10] added that claim is the aspect that most often arises because the claim is only a simple idea, statement, hypothesis, or opinion of an event or phenomenon without supported by evidence and reason.

In data collection and analysis stage, students worked in group to design experiment, conduct experiment and investigation, collect data, and analyze data resulting from experiment. In the syntax of data collection and analysis, the potential aspect of argumentation skill arising is evidence. Through experiment and investigation activity in data collection and analysis stages, the students collect evidence and data to support initial statement or temporary answer that has been made. As evidence, the students found investigation or experiment process which could support the statement of the students, thereby it could be accepted by other students. It is in line with Walker, et al. [37] study finding that the students' ability of giving evidence supporting claim improves after conducting investigation in ADI model.

In argument development stage, students discuss in group to associate the data resulting from experiment in order to organize an argument. In syntax of argument development, potential aspect of argumentation skill arising is reasoning. Through group discussion, students can exchange ideas and collaborate to solve problem [39]. During discussion activity, the students convey the reason (reasoning) of each statement by giving justification connecting the claim to the evidence used. The reason given by the students is the result of thinking and understanding of the problems. Students' understanding is obtained through interaction during group discussion. Akcay [40] stated that working in a group makes students more active in discussing and exchanging ideas with friends about the information obtained so as to help in understanding the information better than just reading the literature.

Argumentation session stage is the one in which the students communicate argument developed by giving them opportunity of proposing, supporting, criticizing, and maintaining their argumentation, explanation, and opinion through class presentation and discussion. Argumentation session facilitates the students to explain and to justify the argumentation developed and to give the students rebuttal against other students' opinion considered as inconsistent with the concept of science. Argumentation session process,

according to Lyewellyn [41] can facilitate the students construct scientific argumentation by means of giving other students the opportunity of expressing opinion and giving rebuttal against the opinion considered as inconsistent with the concept of science. During the argumentation session many students asking his opinion. Kaya et al. [10] also stated that the arguments on high school students greater arise when they engage in the discussion and argumentation session.

Report writing stage is the activity in where the students communicate the result of experiment and data analysis in form of written report. In report writing stage, potential aspects of argumentation skill arising are claim, evidence, and reasoning. For the experimental group, there was a section for answering the question "What is your argument?" in which students presented a good explanation for precisely answering the question in research. Students asserted valid and reliable evidences to support their explanation. The next stage is peer review, in which the students evaluate and apply the knowledge acquired to the real life context. The students evaluated and assessed their friends' report and decided whether the report is acceptable or needed revision based on criteria enclosed in the peer review sheet. In peer review stage, potential aspect of argumentation skill arising is rebuttal. Revision process stage is the one in which the students rewriting the report based on reviewer's feedback. This activity provided to encourage the students to improve their writing ability based on reviewer's feedback. In revision process stage, the potential aspects of argumentation skill arising, namely claim, evidence, and reasoning. The last stage is reflective discussion in which the students conclude the result of research and apply the concept resulting from the experiment. In reflective discussion stage, the potential aspects of argumentation skill arising are claim, evidence, and reasoning.

Overall, the results of the analysis have shown that the use of argument driven inquiry based-module in excretion system material is more effective to enhance students' argumentation skills.

4. CONCLUSION

The argument-driven inquiry-based module is effective to enhance the students' argumentation skill, as indicated with N-gain score of 0.85 in the experimental class, it was higher than that in control class using the common text book provided at school, 0.32. The assessment in this study is limited in aspects of argumentation skills; therefore the following suggestions are given:

- a. In addition to assess argumentation skill, the assessment in the learning process should be included into this aspect of skills (psychomotor), it is an assessment of knowledge (cognitive) and attitude (affective) aspects.
- b. The use of argument driven inquiry-based module should be adjusted with the prevailing syllabus and curriculum, so that the learning process can take place properly.

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