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Argument-Driven Inquiry with Scaffolding as the Development Strategies of Argumentation and Critical Thinking Skills of Students in Lampung, Indonesia

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Abstract Argumentation skills as a form of communication to externalize ideas through scientific discourse is a very important process in learning of biology. Develop strategies argumentation can be one of the alternatives that can help students to improve their critical thinking skills. Students can demonstrate their critical thinking skills, especially in inquiry-based laboratory activities. Therefore, the learning process that uses the inquiry-based laboratory experiments to establish scientific arguments should be designed to develop the argumentation and critical thinking skills of student. The purpose of this study was to investigate the effect of Argument-Driven Inquiry (ADI) strategy, Argument-Driven Inquiry with Scaffolding (ADIS) strategy, and conventional strategy on the argumentation and critical thinking skills of pre-service sience teachers in Faculty of Teacher Training and Education of Lampung University. The study had been carried out in Quasi-Experiment of Pretest-Posttest Nonequivalent Control Group design. The data of the study were collected through argumentation and critical thinking tests before and after the implementation the learning strategies. The data were analyzed by using MANCOVA and were tested in terms of the normality and homogeneity beforehand. The result of the study showed that there were significant differences in the argumentation skill between the learning activities which implemented ADI, ADIS, and conventional strategies. ADIS learning strategy was more effective in improving the students' argumentation skills compared to ADI and conventional learning strategies. Meanwhile, ADIS strategy was as effective as ADI strategy in improving the students' critical thinking skills than conventional strategy. This study also showed that the students' argumentation and critical thinking skills are similar or almost similar between two academic abilities (high and low) when ADIS was applied.

Keywords: *argument-driven inqury, scaffolding, argumentation skills, critical thinking skills, and academic ability*

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1. Introduction

Researches related to argumentation on science in this recent ten years have been dedicated to the development of new curriculum, learning activities, and technologies which support several scientific argumentation in classes [30,36]. The utilization of scientific argumentation is one way to recover the achievement of balance learning objectives of science [35]. The main purpose of science learning includes 3 aspects, namely conceptual, cognitive, epistemic, and social [9]. Firstly, an individual should use some important conceptual structures (such as scientific theories, models, and laws) as well as cognitive process in reasoning a particular topic or problem. Secondly, an individual should recognize and use a scientific epistemic framework to develop and evaluate claims. The last, an individual who is involved in a scientific argumentation should understand and be able to participate in some social process in which knowledge are communicated, represented, argued, and debated within the scope of science.

Argumentation plays an important role on science, yet it is still rarely used in science programs and laboratory activities [8,20,22]. Meanwhile, laboratory activities are an important aspect and necessary for science learning. Students might develop the high order thinking skills, especially in inquisitive laboratory activities [21]. They are able to organize variables which are appropriate for the purpose of research, plan the experimental procedure, decide the best way to interpret findings, and draw scientific conclusions based on findings within a laboratory activity. Through the experiment, students might be able to provide scientific argumentation from the answers of several general research questions given. Argumentation activities gave feedback reformation of hypothesis, change in method, reprocessing data to the experiment activities.

On the other hand, the experiment was the basis for argumentation [22].

The argumentation process is related to a particular critical thinking system [18]. The argumentation skills is one of competences needed since through argumentation one's critical thinking can be developed. Argumentation can be a crucial mean to improve critical thinking skills [28]. Science learning should emphasize the critical reasoning and argumentation skills [8,37]. Learning which involves argumentation aspect might make students need to externalize their thoughts. The externalization is an intra-psychological and a rhetorical argument stages which lead to an inter-psychological and a dialogical argument stages [39]. There are a correlation between students' argumentation and critical thinking skills [21]. Critical thinking skill is influenced by various factors, especially one's thinking structure. The thinking structure might be expressed through language, either spoken or written, which is then called as argumentation.

Based on our research [16] revealed that students' socio-cultural perspective in argumentation does not completely develop yet especially in Basic Biology course in Faculty of Teacher Training and Education, Lampung University. The lower of the students' argumentative discourse affect to the lower of the argumentation quality. The students are difficult to show data or evidences and defend the problems. The causal relationship explanation to a particular phenomenon given to the students is not coherent and the developed evidences are less support and irrelevant.

Lower argumentation skills of students into one of the causes of low student critical thinking skills. The fact of the results of the survey showed that the critical thinking skills of is still low. This is evident from several indicators, among them: students have difficulty in asking the questions and defining the problem, the literacy of the actual problem is still lacking, problem solving analytical and evaluative biology is still low, skills to identify, analyze, and evaluate arguments selectively is still low.

The problems are believed to be due to lack of basic biological learning processes during this course. Students are less encouraged to develop thinking skills and develop argumentative discourse in the learning process. Science learning with inquiry currently emphasize more to practical work rather than involving students in a thinking process through scientific activities such as discussion, argumentation, and negotiation [22].

Laboratory activities less encouraging a process of inquiry because it is only done to prove or test the theory that would normally have been presented in the course or the textbook is used. Students more focused on fair testing and confirmation of the truth that already exist in building knowledge, and only apply the theories and concepts that already exist in practice situations [1]. Another weakness that may occur is the practical guide which has been used. The practical guides explaining the work steps, the equipment should be used, and the procedure is complete. The laboratory activities can lead to passive students if each step is determined. Laboratory activities is a learning experience interacting with students in the learning materials through observation of phenomenon. However, if the only laboratory-oriented activities as a means to explain the statement lecturer or teaching material, then it is repugnant to science [27].

The development of critical thinking and argumentation skills ideally not be treated as a stand-alone activity. This activities must be integrated on increased knowledge and application of science in learning activities. The gap that has been disclosed above need to be addressed and be resolved with an effective learning strategy for these objectives in basic biology course. Learning strategy is considered effective in improving the argumentation and critical thinking skills of students are Argument-Driven Inquiry (ADI). This strategy was developed by Sampson & Gleim [33] as an integrated learning unit which encourage students to participating in an interdisciplinary work, so it might improve students' understanding of important and practical concepts in Biology. ADI is a laboratory-based learning which can improve students' knowledge and skill by participating in several scientific argumentation through reading and wrtiting activities [35].

ADI learning strategy consists of a set of activity and is expected to be able to develop students' active participation in an argumentation discourse and improve the argumentation quality. However, a certain weakness might be found in this strategy, like facilitating an individual spoken argumentation skills through an interactive discussion and peer review of a written argumentation discourse is a difficult task to do without continuous direction. Hence, in order to develop students' argumentation discourse either spoken or written whether in group or individually, a continuous direction, which is called Scaffolding is necessary.

A study by Cho & Jonassen [3] reveals that a group of students who experienced scaffolding argumentation presented more evidences in their argumentation discourse. In order to develop students' argumentation skill, a lecturer might provide scaffolding and several simple assignments until more complex assignments [44]. Scaffolding that is used step by step in learning might encourage students in developing a scientific argumentation which consist of claim, evidences, and reasoning [29].

Scaffolding techniques used in this study has a special characteristic literature. These characteristics are standpoint which functions as an initiate development point of argumentation and stages (initiation, development, and reinforcement) acts as the scaffolding for students in developing the argumentation skill either classically in class, in group, or individually. Standpoint plays an important role in initiating the classical dialectic especially in argumentation activity [10]. Whereas, the stages which are adopted from Larkin [26] and Roshayanti [32] play an important role in improving the argumentation skill for each individual. It is believed that the improvement of an individual argumentation quality will improve the critical thinking skill especially in biological concept. The purpose of the study is to investigate the effectiveness of ADI learning strategy and ADI with Scaffolding (ADIS) strategy to students' argumentation and critical thinking skills.

2. Literature Review

2.1. Argument-Driven Inquiry

Argument-Driven Inquiry (ADI) is a learning strategy that can be used by science educators to bring the

experience of students in laboratory activities become more scientific, authentic, and educational [40]. ADI learning strategy developed by Sampson and Gleim in 2009 to fence the purpose of scientific inquiry as an attempt to develop an argument that provides and supports an explanation for the research question [33,35]. This learning strategies to help students develop the habit of thinking and develop critical thinking by emphasizing the importance role of argumentation in generating and validating scientific knowledge [35].

A series of steps in ADI learning strategy is a guide to design a laboratory-based activities, which consists of eight stages. The eighth stage are interrelated and depend on each other. Every stage is equally important to achieve the objectives and results of the learning process. The current iteration of the ADI learning strategy consists eight stage [33,35], they are: 1) the identification of a task by the classroom teacher that creates a desire for the students to make sense of a phenomenon or to resolve a problem, 2) a laboratory-based experience where small groups of students have an opportunity to generate or analyze data using appropriate tools, 3) the production of a tentative argument that articulates, and justifies an explanation on a medium that can be seen by others, 4) an argumentation session where groups share their arguments and then critique and refine their explanations, 5) a written investigation report generated by individual students that explains the goal of the investigation, the method used, and provides a well-reasoned argument, 6) a double-blind peer review of these reports to ensure quality and to generate valuable feedback for the individual authors, 7) the subsequent revision of the report based on the results of the peer-review, 8) an explicit and reflective discussion about the inquiry.

The difference of this strategy from the others concern 4 aspects [7], namely: 1) students design their own research questions and reach the conclusion by themselves, 2) engage in argumentation by sharing their ideas, supporting and discussing them, 3) peer-review others' lab reports that develop student critical thinking abilities, 4) share their findings with the other students so that they could develop communication and writing skills. Therefore, the strategy ADI could be an effective method in laboratory instruction. Students become more disciplined and produce a better quality of argument, especially in the student's written argument [35]. Students learn how to engage in scientific inquiry and understand the nature of scientific inquiry [34]. Students can understand science as a way to know about science, and this advancing scientific literacy [40].

2.1. Scaffolding

Scaffolding idea was first used in education in 1962 by Vygotsky [19]. The development of a person's ability distinguished on 2 levels, namely actual and potential. The actual development is the ability to complete tasks or solve problems independently, while the potential development under the guidance of an adult or collaborate with peers who are more competent. The distance between them is expressed as a zone of proximal development (Zone of Proximal Development, or ZPD). Potential cognitive development of a person depends ZPD ie when engaging in social behavior. ZPD can be developed through skills trained with adult guidance or peer collaboration exceeds what can be accomplished students themselves, and this is entirely dependent on social interaction. Assistance provided in the ZPD is called scaffolding. Scaffolding can help students achieve a higher level of understanding within their ZPD [38]. Scaffolding can make learning more appropriate for students with changing complex and difficult tasks become more accessible, manageable, and there are in the students' ZPD [31].

Scaffolding as a form of guidance that gradually departed from the actual ability of the students can be done in many ways. One way the use of scaffolding in learning activities proposed by Ellis & Larkin in 1998 as follows: 1) the teacher does it, lecturer modeling how to perform new tasks or difficult, 2) the class does it, lecturer and students work together to perform a task, 3) the group does it, students collaborate in small groups to complete the task, and 4) the individual does it, each student can demonstrate mastery of their tasks individually [26]. Scaffolding is temporary assistance, so its must be adjusted from time to time and not constant, gradual guidance released when a student has been able to master a certain competence independently [42].

Several researches related to an argumentation in learning have been trying to develop students' argumentation skill through the implementation of scaffolding. Some of which utilize online based multimedia facilities. Clark & Sampson [5] used online Personally-Seeded Discussions program. The students used online facilities to develop principles to describe the obtained data. The students was placed in discussion groups consisting of members who had different principles so each student could consider and criticize other's principles. This study showed the effectiveness of this program as the scaffolding of a scientific argumentation in online forum. Cho & Jonassen [3] studied the implementation of an argument scaffolding in online forum which facilitates students to develop coherent argumentations during the answering process. The result of the study showed that the argumentation scaffolding during the answer session in the group discussion activities can improve the production of coherent argumentations.

Many studies show that the scaffolding is used to develop a discourse argumentation for learning of science. However, the extent of scaffolding applied in ADI learning strategy has not been addressed in the literature to the best knowledge of the researcher.

3. Method

The study had been carried out in pretest-posttest non-equivalent control group design. The learning strategies used during the experimentation were Argument-Driven Inquiry (ADI) strategy, Argument-Driven Inquiry with Scaffolding (ADIS) strategy, and conventional strategy. This study examined the effect of the three learning strategies on agumentation and critical thinking skills of pre-service science teachers in Faculty of Teacher Training and Education of Lampung University in Lampung, Sumatera, Indonesia. The study had been carried out in a 3 x 2 factorial design (Figure 1).

Academic Ability	Learning Strategy (S)		
	ADI (S_1)	ADIS (S_2)	Conventional (S_3)
High (A_1)	A_1S_1	A_1S_2	A_1S_3
Low (A_2)	A_2S_1	A_2S_2	A_2S_3

Figure 1. The 3 x 2 Factorial Design

The population of the study were all of students of Mathematics and Science Education Department which is divided into 4 study program, they are: biology education, chemistry education, physics education, and mathematics education which each has basic biology subject. The 180 pre-service science teachers consisting of 60 participants in the conventional group, 60 participants in ADI group, and 60 participants in ADIS group were selected as the samples of the study. The samples consisted of 155 females and 25 males. The samples were chosen through random sampling technique from each study program.

Learning activities by use of ADI strategy includes 8 stages [33,35]: 1) identification of task, 2) collect and analyze data, 3) production of tentative argument, 4) an argument session, 5) a written investigation report, 6) peer-review of these reports, 7) report revision process, and 8) reflective discussion. Meanwhile, learning activities by use of ADIS strategy include 3 stage, namely initiation, development, and reinforcement.

The initiation stage consist 8 steps, they are: 1) development of class standpoint, 2) collect and analyze of class data, 3) production of class tentative argument, 4) the interactive session of class argument, 5) a written investigation of class report, 6) peer-review of class report, 7) revision process of class report, and 8) reflective discussion. *The development stage* consists of 5 steps, they are: 1) development of group standpoint, 2) collect and analyze of group data, 3) production of group tentative argument, 4) the interactive session of group argument, and 5) reflective discussion. *The reinforcement stage* consists of 5 steps, they are: 1) development of individual standpoint, 2) collect and analyze of individual data, 3) production of individual tentative argument, 4) the interactive session of individual argument, and 5) reflective discussion. Furthermore, the conventional strategy of conducting a traditional laboratory activities.

The teaching material apllied in the study covers: the structure and function of plantations and animals, living things reproduction, metabolism, Mendew law and human nature inheritance, organism's interaction to environment, and evolution. The data of the study were obtained through the pretest and posttest. The data were measured by an integrated essay test to measure argumentation and ctirical thinking skills. The test was developed based on the basic biology competence for pre-service science teacher as mentioned above. The argumentation test was developed base on 'the competiting theories strategy' by Osborne [30]. The scoring rubric of the argumentation skill was adapted from Toulmin Argumentation Pattern (TAP) based on Osborne [30] framework as presented in Table 1.

Based on the researchers' synthesis to several related literature such as Ennis [12] and Krulik & Rudnick [24], the critical thinking test aimed at measuring the students' skill related to provide elementary clarification, construct basic support, inferring, provide advanced clarification, and organize strategies and tactic. The scoring rubric of the critical thinking skill was adapted from Hart [15] with 0-4 range score. The development of the rubric was based on the required answers which reflected the students' thought in written form which presented logical, accurate, and coherent ideas.

Table 1. Analytical framework used for scoring the argumentation skills

Score	Criteria
5	Argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim
4	Argumentation has arguments consisting of a claim versus a claim with either data, warrants or backings but do not contain any rebuttals.
3	Argumentation has arguments with a series of claims or counterclaims with either data, warrants or backings with the occasional weak rebuttal.
2	Argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counterclaims as well.
1	Argumentation displays an extended argument with more than one rebuttal

The data of the study were in form of pretest and posttest scores which were tested statistically by using MANCOVA with significant value 5%. If it was found any significant learning outcomes between the groups, the data were tested by using Least Significant Difference (LSD) test. Before the data analysis conducted by using MANCOVA, the assumption test were done, including normality testing of One-Sample Kolmogorov-Smirnov Test and homogeneity testing of Levene's Test The Equality of Error Variance.

Table 2. The Summary of All The Normality Testing and Homogeneity Testing

Descriptor	Learning Strategy	Academic Ability	Normality Testing				Homogeneity Testing	
			Pretest Value	Sig	Posttest Value	Sig	Levene's Test Value	Sig
Argumentation skills	ADI	High	25,46	0,078	65,72	0,527	2,120	0,065
		Low	31,08	0,367	65,59	0,058		
	ADIS	High	27,12	0,503	72,50	0,729		
		Low	26,29	0,387	76,33	0,756		
	Conventional	High	28,03	0,823	64,63	0,100		
		Low	23,80	0,412	54,77	0,225		
Critical thinking skills	ADI	High	21,38	0,624	72,01	0,779	1,460	0,205
		Low	17,69	0,290	67,48	0,921		
	ADIS	High	21,57	0,843	71,40	0,897		
		Low	16,33	0,746	62,01	0,786		
	Conventional	High	18,71	0,884	63,08	0,976		
		Low	15,52	0,670	56,77	0,637		

4. Result

The data used in this study was obtained from results of pretest and postest. All the test items have been fulfilled the validity. The result of the reliability test showed that the items employed in the essay test have a high reliability index, which are 0,690 for argumentation test and 0,773 for ciritical thinking test. The results of the normality testing and homogeneity testing showed that the data were normally distributed and almost all the variances were homogeneous. All the normality testing and homogeneity testing results are presented on Table 2.

The summary of MANCOVA result of argumentation and critical thinking skills related interaction of the learning strategies and academic ability is displayed on Table 3 and Table 4. Based on Table 3, it can be seen that the covariate effect (pretest) on the argumentation and critical thinking skills is not significant.

Table 3. Summary of MANCOVA Test Results on The Effect of Learning Strategies to the Argumentation and the Critical Thinking Skills

Source	Df	F	Sig
Pretest Argumentation Skills	3	2,068	0,106
Pretes Critical Thinking Skills	3	1,281	0,283
Learning Strategy	6	8,207	0,000
Academic Ability	3	4,978	0,002
Learning Strategy* Academic Ability	6	1,595	0,148

Table 4. Summary of MANCOVA Test Results on The Effect beetween Subject

Variety Sources	Dependent Variables	JK	df	Mean Square	F	Sig
Pretest Argumentation Skills	Argumentation skills	0,151	1	0,151	1,722	0,191
	Critical thinking Skills	295.203	1	i295.203	4.339	0,039
Pretest Critical Thinking Skills	Argumentation skills	0,018	1	0,018	0,207	0,650
	Critical thinking Skills	170,859	1	170,859	2,512	0,115
Learning Strategies	Argumentation skills	1,309	2	0,654	7,468	0,001
	Critical thinking Skills	1727,968	2	863,984	12,701	0,000
Academic Ability	Argumentation skills	0,008	1	0,008	0,087	0,769
	Critical thinking Skills	876,298	1	876,298	12,882	0,000
Learning Strategies*Academic Ability	Argumentation skills	0,488	2	0,244	2,786	0,064
	Critical thinking Skills	81,667	2	42,503	0,620	0,550

Based on the effect between subjects are presented in Table 4, it can be seen the effect of the argumentation skill covariate is not significant in terms of the argumentation skill, while its on the critical thinking skill is significant. The effect of academic ability on the argumentation skill is not significant even though its effects on the critical thinking is significant. It is indicated that high and low academic abilities differently influence the achievement of the critical thinking skill but not on argumentation skill. Furthermore, the interaction effect of learning strategies and academic ability on the argumentation and critical thinking skills is not significant. Regarding comparison of mean corrected argumentation and critical thinking skills on the three learning strategies and academic ability is presented in Table 5 and Table 6.

Table 5. Comparison of Mean Corrected Argumentation and Critical Thinking Skills beetwen Three Strategies

Dependent Variables	Learning Strategy	Pretest	Postest	Difference	Corrected	Notation
Argumentation Skills	Argument-Driven Inquiry (ADI)	28,27	65,65	37,38	65,42	a
	Argument-Driven Inquiry with Scaffolding (ADIS)	26,70	74,42	47,72	74,46	b
	Conventional	25,92	59,70	33,78	59,89	a
Critical Thinking Skills	Argument-Driven Inquiry (ADI)	19,54	69,75	50,21	69,104	a
	Argument-Driven Inquiry with Scaffolding (ADIS)	18,96	66,71	47,75	66,432	a
	Conventional	17,11	59,92	42,81	60,836	b

Table 6. Comparison of Mean Corrected Argumentation and Critical Thinking Skills beetwen Two Academic Ability

Dependent Variables	Academic Ability	Pretest	Postest	Difference	Corrected	Notation
Argumentation Skills	High	26,870	67,740	40,870	67,757	a
	Low	27,055	65,697	38,641	65,714	a
Critical Thinking Skills	High	20,560	68,829	48,269	67,562	a
	Low	16,512	62,086	45,574	63,353	b

Based on LSD test, it is found that there is a significant difference in the argumentation skill achievement of students between ADI strategy, ADIS strategy, and conventional strategy. The argumentation skill of students which experiencing ADIS strategy is inclined higher than others. Comparison of mean corrected argumentation skill between three strategies are presented in Table 5, it can be seen that the achievement of the argumentation skills in the implementation of ADIS strategy is more effective than ADI strategy and conventional strategy. Table 5 also indicated that there is no significant difference in terms of the critical thinking skills achievement of students between ADI strategy and ADIS strategy. Meanwhile, there is significant difference in terms of the critical thinking skills achievement of students between ADI strategy and conventional strategy. The mean corrected of the critical thinking skills in ADI strategy is higher than conventional strategy. Furthermore, there is the difference in terms of the critical thinking skill achievement between ADIS and conventional strategy is significant. The mean corrected of the critical thinking skills students in ADIS strategy is higher than conventional strategy. All of these

results indicates that ADIS strategy was as effective as ADI strategy in improving the students' critical thinking skills than conventional strategy.

Based on Table 6, it can be seen that the achievement of students with high academic ability and low academic ability on the argumentation skill is not differently significant even though on the critical thinking is differently significant. Comparison of mean corrected critical thinking skills between two academic ability showed that achievement of the critical thinking skills of the high academic ability students is higher than the low academic ability students.

5. Discussion

The findings of the study reveal that the implementation of scaffolding in Argument-Driven Inquiry strategy (ADIS) in the Basic Biology course is more effective in improving the students' argumentation skill compared to ADI and conventional learning strategies. It is believed that that standpoint, as the initiate point in the development of argumentation and stages (initiation, development, and reinforcement), is effective as scaffolding for the students to improve the argumentation skill. The lecturer needs to develop scaffolding for enhancing the students' argumentation skill. Scaffolding is an act of providing some facilities to students during the beginning of learning activities, then the facilities are decreased and let the students take the opportunity to have a bigger responsibility after they can do the tasks themselves[3].

Standpoint is the starting point in the development of argumentation discourse have function as a functional element of an argument [6,13]. Standpoint developed in accordance with the topic of material every stage. Determination standpoint for each stage adapted to the respective characters of materials, where each particular stage only to a particular standpoint. The research showed that standpoint can stimulate students to practice developing argumentation discourse. Referring to the standpoint, the students are required to develop their claims that accompanied the warrant support and strong backing. Students who responded well standpoint will produce a more complex argumentation discourse, so the argument quality is very good .

In this research, on the initiation stage, the students were divided into two groups with opposing claims. This is a scaffolding for the students to begin the development of the argumentation discourse by trying to develop warrant and backing. On the development stage, each group is free to decide the claims. This facilitates the students to develop their argumentation skills. This stage is expected to be able to improve the quality of the group's argumentation discourse. On the reinforcement stage, the students have their own argument, so in this stage the individual argumentation is brought to the broaden argumentation discourse.

The results of this study showed that the students in the conventional and ADI groups tend to provide explanation which are based on claims with data, warrant or backing with weak rebuttal in their written argument. While, students in the ADIS group are able to develop a clear rebuttal with several claims or counter claims (score 4) in the explanation. However, there is no student who can provide an argument that is supported with more than one clear rebuttals (score 5) either in group ADIS, ADI, or conventional. It is believed that scaffolding used in ADI strategy framework in this study is able to motivate the students to broaden their argument.

The students' argumentative discourse is classified into fourth scores. The following excerpt is the example of the students argument for "4 score".

Score 4: Argumentation has arguments consisting of a claim versus a claim with either data, warrants or backings but do not contain any rebuttals.

Q5: two students were discussing an electron transport in a metabolism reaction. Here is their explanation.

Student A: there is a similarity in the basic mechanism in producing ATP between chloroplast and mitochondria. Chloroplast and mitochondria are producing ATP through chemiosmosis mechanism.

Student B: there is an oxidative phosphorylation in mitochondria and chloroplast.

There is indeed a similarity and a difference of oxidative phosphorylation between chloroplast and mitochondria (CLAIM). Chloroplast and mitochondria are producing ATP through chemiosmosis mechanism. The difference is mitochondria transfer the chemical energy from food molecules to ATP, while chloroplast transforms the light energy becomes the chemical energy (DATA). It is incorrect if it is explained that the chain of electron transport which is formed in the mitochondria membrane pumps the proton through the membrane as the electron passes carrier compounds which should be more electropositive, yet they tend to be more electronegative (REBUTTAL). In short, oxidative phosphorylation is a redox reaction of an electron transport chain which transforms the redox energy becomes proton kinesthetic force, potential energy which is kept in the form of gradient H+ through the membrane. The synthase complex ATP on the membrane duplicates the ion H+ diffusion to descend the gradient with ADP phosphorylation (WARRANT).

Students are able to develop their skill and knowledge, and provide more evidences in the argumentation discourse by implementing scaffolding [4]. Students who experience scaffold are more focus on claims and reasons, since they are the most important elements of problem solving [3]. It means, the answers of the given questions are stated in the form of claims and are supported with reasons. On the other hand, warrant, backing, and rebuttal act as the supporting aspects. Data or evidences are the main entities in the construction of an argument. Meanwhile, a group who does not experience scaffold focusses on how to support their claims with evidences. Students often do not use enough suitable evidence and evidence to justify the argument that they produce [2]. Students often do not use criteria that are consistent with the standards of the scientific community to determine the ideas, accept, reject, and modify or distort the ideas of others [25]. They tend to disparage and disregard the evidence in reaffirming a misunderstanding. When constructing arguments, students often focus on only one part of the evidence rather than considering an entire set [2]. While, the way scientists think is how he was able to present evidence as the basis for an argument or claim related to the facts through a premise [8].

Even though there is a significant different on the argumentation skill score between ADI and ADIS groups, there is a no significant similarity on the critical thinking skill between ADI and ADIS groups. The result of the study showed that ADIS strategy is as effective as ADI strategy in improving the students' critical thinking skill compared to conventional strategy.

Students are directed to design and carry out the investigation, collect and analyze data, communicate, and justify their ideas with one another in the ADI and ADIS learning strategy. Furthermore, students write investigation reports in an interactive session to share arguments and engage in peer-review. Thus, students in ADI and ADIS class have a chance to practice the scientific method and engage in scientific argumentation, so that developing critical thinking skills. Science education should emphasize critical thinking and argumentation [37].

The students in conventional group provide explanation based on conclusion in their written report and report the data found during the experiment. In the report which is written by ADI and ADIS students, there is a part in which the students provide explanation which are actually the answer of the research question, supported with explanation and valid evidences. In this case, due to a method, a difference in writing a report can be a reason to the improvement of the critical thinking skill. Critical thinking is a reflective thinking that is logic or based on reasoning that aims at determining what needs to believe and what needs to do [11]. Critical thinking utilize the principle of thinking process to analyze argument and bring knowledge to each meaning and interpretation, develop cohesive and logic reasoning patterns, and understand the assumption and bias that underlay each position.

An opportunity to refute or prove that one's idea is wrong in the "argumentation session" encourages the students to report their laboratory activities easily and facilitates them to use the rebuttal during discussion. An individual who can think critically might be able to raise accurate questions, collect relevant information effectively and efficiently, organize information creatively, possess logical reasoning of a particular information, and draw consistent and reliable conclusions [14]. Students' argumentation skill correlates positively to their critical thinking skill [21]. The critical thinking skill is determined by an individual thinking structure which can be expressed through spoken or written argumentation.

The achievement of students with high and low academic abilitiesis is the same in related to the argumentation skills, whereas on the achievement of critical thinking is different. The achievement of the critical thinking for students with high academic ability higher than students with low academic ability. These results showed that there is effect of student's academic abilities on the critical thinking skills. High-ability students are number of students who have the initial state is higher than the average grade. While, low-ability students is the number of students who have the initial state is lower than or equal to the average grade. High-ability students have the initial state is better than the initial of low-ability students. This leads to high-ability students have confidence more than low-ability students [17]. The success of the learning process is largely influenced by the characteristic possessed by students, either as individuals or as a group.

Various factors affect the success of students with high academic ability namely: a lecturer and environmental lectures, peers, family and the role of students themselves [43]. Lecturer and environmental lectures possess active role in promoting learning, develop thinking skills, creating a zone of effective learning, promoting success, providing effective feedback, improve motivation and accept individual differences. Every level of education should focus on the development of thinking [23]. Lecturer should be done by giving the opportunity to the students to think by doing activities that require the thinking abilities.

The interaction effect of learning strategies and academic ability on the argumentation and critical thinking skills is not significant. It that showed that ADIS learning strategy is able to equalize the achievement of high and low academic abilities students, because the characteristics of ADIS learning strategy complement to one another. It should be noted in the study is to reduce the distance between the upper and lower ability students in the process and learning outcomes [41].

6. Conclusions

Based on the above discussion, ADIS strategy is inclined having a higher potency in enhancing the achievement of high and low academic ability student in terms of argumentation and critical thinking skills. It is believed that ADIS strategy has appropriate learning stages needed by high and low academic ability students so that it enhances their achievement. Being involved in an argumentation and a production of spoken and written argument in this study, the students are able to improve their argumentation and critical thinking skills. This study provide a contribution for science teachers and lecturers to implement learning strategies which involve scaffolding in classroom argumentation to develop the science and the writing ability as well as the critical thinking skill of the students.

The students' argumentative discourse is lower in the sense of providing argument that is supported with more than one rebuttal. In the other words, lecturers cannot develop a good standpoint for the sake of inquiry process and argumentation development between the students. An effort to optimize the utilization of standpoint as scaffolding is necessary to defend the argumentation quality socially and to improve the argumentation quality individually. The improvement of the argumentation quality might affect to the improvement of the critical thinking skill of the students.

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