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THE EFFECT OF PDEODE (PREDICT-DISCUSS-EXPLAIN-OBSERVE-DISCUSS-EXPLAIN) LEARNING STRATEGY IN THE DIFFERENT ACADEMIC ABILITIES ON STUDENTS' CRITICAL THINKING SKILLS IN SENIOR HIGH SCHOOL

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Abstract:
Critical thinking is one of the basic skills in the 21st century. Based on the TIMSS study (The Trends in International Mathematics and Science Study) on 2007, found that Indonesian student are not able to show some abstract and complex concepts in biology. The student cannot understand the complexity of life creatures and their relationship with the environment. This quasi-experimental research aims to determine: (1) differences of students' critical thinking skills between PDEODE learning and conventional learning, (2) differences of students' critical thinking skills between those at higher and lower academic abilities, and (3) the critical thinking skills of students due to the interaction between learning strategy and academic ability. The research design was a pretest-posttest non-equivalent control design. The sample was 40 students of State Senior High School 1 Makassar and Islamic Senior High School Athirah Makassar. The research has been carried out during semester 1 of academic year 2015-2016. Data were obtained by the pre-test and post-test using essay test. Data were analysed using ANACOVA Test. The data analysis showed that learning strategy, academic ability, as well as interaction between learning strategy and academic ability affect the students' critical thinking skills significantly. PDEODE learning strategy affects the students' critical thinking skills as much as 71.43% higher than conventional learning. High academic ability affects the students' critical thinking skills as much as 67.03% higher

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than the low academic ability. It is uncovered too that students with low academic in PDEODE class with high academic students in conventional class increase critical thinking skills in the same level. It means that PDEODE learning strategy could help the low academic student to increase their critical thinking skill. PDEODE learning strategy in high academic ability is best one to increase critical thinking skills.

Keywords: PDEODE learning strategy, critical thinking skills, academic ability

1. Introduction

Thinking skills are one of the basic skills in the 21st century. Thinking skills combined with the other life skills will enable students to have the ability and success in contributing to the fast changing world (Greenstein, 2012). One of the thinking skills is the critical thinking skill. Critical thinking is a process of intellectual disciplines which are actively and skilfully constructing concepts, applying, analysing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to build believes and actions (Scriven and Paul, 2007). Critical thinking is also referred to as metacognition, or the process of "*thinking about thinking*" (Flavell, 1979).

Critical thinking skill is very essential for students because it enables the students to deal with social, scientific, and practical problems effectively (Shakirova, 2007). The students having critical thinking skill will be able to solve problems effectively. To be effective in the working life and everyday life, having knowledge or information solely is insufficient. Students should be able to solve problems in order to make effective decisions. Therefore, students should be able to think critically (Snyder and Snyder, 2008). Students who have critical thinking skill are able to construct knowledge useful in the future to increase students' motivation in their everyday lives (Lai and Viering, 2012).Various references have also shown a positive correlation between students' critical thinking skill and their concept gaining (Meha, 2006; Hilmiah, 2006; Yuanita, 2006). This suggests that it is important to develop students' critical thinking skill in the learning process to increase students' cognitive learning results and to develop their life skills in this 21st century.

Based on the results of the TIMSS research in 2007 *(The Trends in International Mathematics and Science Study),* the Indonesian students' ability in science was in the position of 35 from 49 participating countries with the achievement score of 433, and was still below the international average score of 500. It was also shown that Indonesian

students are not capable of several aspects: (1) showing some abstract and complex concepts of biology, (2) understanding the complexity of living things and their relationship with the environment, and (3) giving written explanations to convey scientific knowledge (Martin *et al*, 2008).

The results of PISA *(the Programme for International Student Assessment)* international research in 2006 showed that the science literacy of Indonesian students ranked the 50th out of 57 countries. The aspects of scientific literacy measured in this research were the use of knowledge and problem identification to understand the facts and the decision about nature and the changes occurring in the environment. On the international scale, the ability of science literacy is divided into six levels. Based on this ability level, 20.3% of Indonesian students is under level 1 (score below 334.94), 41.3% is at the level 1 (score of 334.94 to 409.54), 27.5% is at level 2 (score of 409.54 to 484.14), 9.5% is at level 3 (score of 484.14 to 558.73), and 1.4% is at level 4. There are not any Indonesian students who are at level 5 or level 6. It indicates that only about 27.5% of Indonesian students have sufficient scientific knowledge to provide possible explanations of familiar contexts or make conclusions based on simple observations. Most of Indonesian students (41.3%) have limited scientific knowledge that can only be applied to some familiar situations. They can only present scientific explanation if the facts were clearly and explicitly provided. The results of both research showed that in general the critical thinking skills of Indonesian students are not yet developed in the learning process (OECD, 2007).

The critical thinking skills of Indonesian students are still low (Dharma, 2008). This is because most of the learning process, especially in science subjects (biology), has not implemented meaningful learning, so that most students experience difficulties in developing their critical thinking skills (Tindangen, 2006). The current learning process has not encouraged the students to develop their thinking skills yet. Students are mostly instructed to memorize, remember and store any information, but they are not urged to understand the information or to connect it with their everyday lives (Sanjaya, 2008). The results of the survey (Ramdani, 2010; Muhfahroyin 2010; Efendi, 2012; Tumbel, 2011) suggest that the biology learning in school has not yet given adequate attention to the development of students' critical thinking skills. The thinking empowerment efforts through Biology learning have not been well planned. This is in line with Corebima (2005) who reported that teachers at elementary, junior or senior high school levels did not pay much attention on the aspects of thinking skills in the learning process. Galyam and Le Grange (2005) also revealed that science learning was still dominated by the *content transmission* paradigm that is, transferring

information from the teachers to students. As a matter of fact, this approach is only suitable for the students who have high academic ability, but it is not suitable for students who have low academic ability.

Based on the results of the observations from several schools in Makassar in January 2015, there were still many Biology learning oriented on developing and testing students' memory. The learning process tended to be theory memorization and not based on students' experience, so the students' ability is merely understood as memorization skill. Such learning processes would not be able to develop students' thinking skills. The students did not have much chance to construct, analyse, evaluate, and deduce their knowledge, as well as determine the solution as the results of their thinking activities. Classroom learnings have not addressed on the difference of students' academic ability. The senior high schools in Makassar generally place the students into heterogeneous classes. It means that the students in one class are from various levels of academic ability. Teachers should pay attention on the difference of the students' academic ability. The learning strategies used should be able to accommodate students with varying levels of academic ability. Some learning strategies have significant potential in empowering the critical thinking skills of the students having high or low academic ability (Corebima, 2007). Therefore, the teacher, as a learning facilitator, should be able to select the appropriate learning strategies which can empower the academic ability of heterogeneous students.

These problems must be immediately overcome by using learning strategies that are able to empower the students' critical thinking skills and communication. One of the alternative solutions is PDEODE *(Predict-Discuss-Observe-Explain-Discuss-Explain)* learning strategy. PDEODE learning strategy is developed from the POE *(Predict-Observe-Explain)* learning strategy (Costu, 2008). POE is a learning strategy that uses a constructivist approach. POE can facilitate the students to improve their learning results (Puriyandaari et al, 2014; Restami et al, 2013; Rahayu et al, 2013).

PDEODE learning strategy emphasizes that the students play an active role in the learning process where students discover and construct their own knowledge. At this learning strategy, the students will think logically and theoretically based on the proportions and hypothesis. They also can make decisions based on the conclusions. Meanwhile, teachers play the roles as a motivator and facilitator to the students in the learning activities. Teachers guide, direct, and help students, so they can interact with their environment and everyday life. The problems given to students are related to the students' environment and surroundings. Therefore, they can think and find the solutions to the problems according to their cognitive development. The

students will have the freedom to investigate the problems individually or cooperatively with the other students to solve the problems (Costu, 2008).

This strategy provides the students with the opportunity to express their prior knowledge regarding with the material given, to cooperate with the other students during the discussion, to exchange opinions with the other students, to change their concepts about the knowledge they possess (Kolari and Ranne, 2003). The conceptual change that occurs is a change from the students' initial concept to a newer concept of knowledge which is already proven correct through demonstrations or experiments. The results of the research by Costu (2008) showed that PDEODE could facilitate the students to understand situations or problems in their everyday lives, and it could help the students acquire better concept understanding.

A continuous implementation of this learning strategy will be able to provide positive feedback and develop the learning towards *student centered.* A *student centered* learning strategies can help students to learn better, and to develop their ability and confidence to evaluate their knowledge. In addition, this learning strategy can improve students' motivation. Students were more active in interacting with the other study groups and active in constructing their own knowledge (Kolari et al., 2005). Through this learning strategy, students can communicate with the other students to discuss their opinions and conflicts, to make predictions, interpretation and explanation in building or constructing their knowledge and the students can correct their misconception through discussion and demonstration (Kolari and Ranne, 2003). It can support the development of students' critical thinking skills.

This research aims to investigate: (1) the differences in the learning results of the students taught by using PDEODE learning strategy and those taught by using the conventional learning strategy, (2) the differences in the learning results of the students having different academic ability, and (3) the differences in the learning results because of the interaction between PDEODE learning strategy and academic ability. The results of this research are expected to be valuable in the development of science and its applications.

2. Method

This research uses a quantitative approach, which is a quasi-experimental research (Cresswell, 2013; Cohen et *al*, 2011). The design of this research was pretest-posttest non-equivalent control group design (Cohen et *al*, 2011). The design of this research can be seen in Table 1.

Table 1: Research design

Class	Pre-test	Treatment	Post-test
Experiment	O_1	X	O_2
Control	O_3		O_4

(Cohen et al, 2011: 96)

The independent variables in this research were learning models, namely PDEODE learning strategy and the conventional learning strategy, as factor A. In this research, a moderator variable was also used, namely the high academic ability and the low academic ability, as factor B. The dependent variables were the students' critical thinking skills, communication skills, and cognitive learning results. Therefore, this research used factorial design 2 x 2. The factorial design is illustrated in Table 2.

Table 2: Factorial design 2 x 2

Academic ability (K)	**Learning models (S)**	
	PDEODE (S1)	**Conventional learning (S2)**
High (K1)	S1K1	S2K1
Low (K2)	S1K2	S2K2

The implementation procedures of the treatment combination based on the factorial design above are shown in Table 3.

Table 3: The combination Based on factorial 2 x 2 research design

Pre-test	Treatment	Post-test
O1	S1K1	O2
O3	S1K2	O4
O5	S2K1	O6
O7	S2K2	O8

Information:
S1 = the class of PDEODE learning model
S2 = the class of conventional learning model
K1 = higher academic ability
K2 = lower academic ability
O1, O3, O5, O7 = pre-test scores
O2, O4, O6, O6 = post-test scores

The population of the research was all students of class XI senior high schools in Makassar in the first semester of the 2015/2016 academic year. The schools selected as the research area were those which implemented 2013 curriculum in the first semester of the 2015/2016 academic year. The sampling was done by using *simple random sampling* technique after the equality test was initially given using the *grouping test.* From the selected classes, class XI Natural Science 4 of public senior high school 1 Makassar was used as the control class, and Class XI Natural Science 2 of senior high school Islam Athirah Makassar was used as the experimental class. Each of the treatment class treatment was divided into three levels of academic ability (high, middle, and low) by using a *placement test.* In this research, the subjects were only the students having high and low academic ability.

The data were obtained by giving pre-tests and post-test using the *essay test.* The data obtained were then tested for the normality and homogeneity. This research hypothesis was tested by using analysis of covariance (ANCOVA) by *SPSS 22.0 software for Windows.* The data were then analysed using the post hoc LSD.

3. Findings and Interpretation

3.1 Data of Critical Thinking Skills Based on the results of *pre-test* and *post-test*

Table 4 shows the data description of the students' initial critical thinking skills and Table 5 shows the data description of the students' final critical thinking skills. The data were obtained from the pre-test and post-test in the experimental class *(PDEODE)* and control class (conventional).

Table 4: Summary of the data Description of the Critical Thinking Skills Based on the results of the Pre-test

Classes given learning strategy consists of 2 levels	There are 2 levels of academic ability	mean	Std. deviation	N
1 = control	1 = Low	13.90	4.748	10
	2 = high	24.90	6.315	10
	Total	19.40	7.836	20
2 = experiments	1 = Low	14.70	4.692	10
	2 = high	25,50	9.396	10
	Total	20.10	9.107	20
Total	1 = Low	14,30	4.612	20
	2 = high	25.20	7.797	20
	Total	19.75	8.393	40

Table 5: Summary of the data Description of the Critical Thinking Skills Based on the results of the Post-test

Classes given learning strategy consists of 2 levels	There are 2 levels of academic ability	mean	Std. deviation	N
1 = control	1 = Low	19.50	5.039	10
	2 = high	53.20	5.266	10
	Total	36.35	18.001	20
2 = experiments	1 = Low	53,00	9.944	10
	2 = high	71.90	4.977	10
	Total	62.45	12.352	20
Total	1 = Low	36.25	18.820	20
	2 = high	62.55	10.812	20
	Total	49.40	20.171	40

The data description of the students' initial critical thinking skills and final critical thinking skills of the experimental class and the control class is presented in a bar chart to make it more easily understood. A bar chart of the students' critical thinking can be seen in Figure 1.

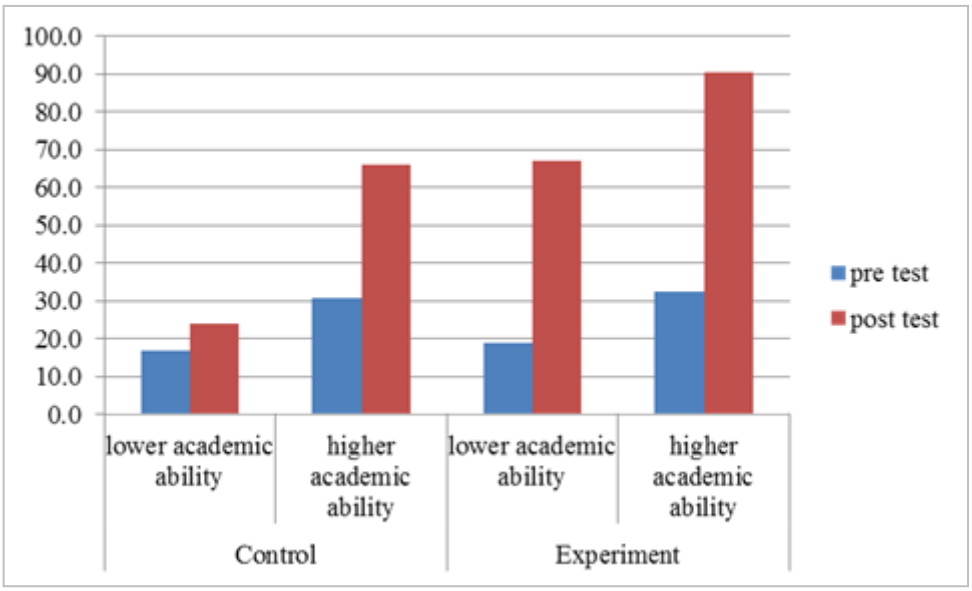

Figure 1: Bar Chart of the mean score of the Pre-test and post-test of the Students' Critical Thinking Skills

Figure 1 show that the mean score of the initial critical thinking skills of the students having low academic ability in the conventional class was 13.9, and the mean score of final critical thinking skills was 19.5; there was an increase in the mean score of the critical thinking skills in this class as much as 0.29%. The mean score of the initial

critical thinking skills of the students having high academic ability in the conventional class was 24.9, and the final critical thinking skills was 53.2; there was an increase in the mean score of the critical thinking skills in this group as much as 113.65%. In PDEODE class, the mean score of the initial critical thinking skills of the students having low academic ability was 14.7, and the mean score of the final critical thinking skills was 53; there was an increase in the mean score of the critical thinking skills in this group as much as 260.54%. The mean score of the initial critical thinking skills of the students having high academic ability in PDEODE class was 25.5, and the mean score of final critical thinking skills was 71.9; there was an increase in the mean score of the critical thinking skills in this group as much as 181.96%.

The data of the critical thinking skills from the students' pre-test and post-test was then analysed using Ancova, and the results are summarized in Table 6.

Table 6: The summary of results of the Ancova test on the Critical Thinking Skills based on the results of *pre-test* and *post-test*

Source	Type III Sum of Squares	df	mean Square	F	Sig.
corrected Model	23064.906 [a]	4	3576.598	80.182	, 000
intercept	13048.715	1	7891.862	176.924	, 000
XHB	76 231	1	29.794	,668	, 419
CLASS	10972.469	1	6740.358	151.109	**, 000**
KA	5486.967	1	3483.391	78.093	**, 000**
CLASS * KA	869 411	1	545.518	12.230	**.001**
Error	2584.869	35	44.606		
Total	178543.000	40			
corrected Total	25649.775	39			

3.2 Learning strategy

Based on the results of ANCOVA test in the table above, the significance value of the learning strategies was 0.000 or less than 0.05. It means that the null hypothesis was rejected, and the research hypothesis was accepted. It means that there were significant differences in the critical thinking skills between the experimental class (PDEODE learning strategy) and control class (conventional learning strategy). This shows that learning strategies have an effect on students' critical thinking skills.

Table 7 below shows the results of the corrected mean score of the experimental class and control class.

Table 7: Comparison of the corrected mean score between the learning strategies on the Critical Thinking Skills

CLASS	XBK	YBK	DIFFERENCE	BKCOR
1 = control	19.40	36.35	16.95	**36.40**
2 = experiments	20.10	62.45	42.35	**62.40**

After the mean scores are compared, it appears that the corrected mean score in the experimental class was 62.40, and the corrected mean score in the control class was 36.40. It shows that PDEODE learning strategy has an effect on students' critical thinking skills 71.43% higher than the conventional learning strategy does.

3.3 Academic ability

The results of the ANCOVA test in Table 6 above show that the significance value of the academic ability was 0.000 or less than 0.05. It means that the null hypothesis was rejected, and the research hypothesis was accepted. It means that there is a significant difference in critical thinking skills between the students having high academic ability and the students having low academic ability. It indicates that academic ability has an effect on students' critical thinking skills.

Table 8 below shows the results of comparison of the corrected mean score of the high academic ability and the low academic ability.

Table 8: Comparison of corrected mean score of the Academic Ability on Critical Thinking Skills

KA	XBK	YBK	DIFFERENCE	BKCOR
1 = Low	14,30	36.25	21.95	**37.00**
2 = high	25.20	62.55	37.35	**61.80**

After the mean scores are compared, it appears that the corrected mean score of the high academic ability was 61.80, and the corrected mean score of the low academic ability was 37.00. These results indicate that the high academic ability has an effect on students' critical thinking skills 67.03% higher than the low academic ability does.

3.4 The Interaction of the Learning Strategies and Academic Ability on the Learning results

The results of the ANCOVA test in Table 6 above show that the significance value of the interaction between learning strategies and academic ability was 0.001 or less than 0.05. It means that the null hypothesis was rejected and the research hypothesis was

accepted. It means that there is a significant difference in the critical thinking skills due to the interaction between learning strategies and academic ability. It indicates that the interaction between learning strategies and academic ability has an effect on the students' critical thinking skills. The results of the post hoc (LSD) test showing the effect of the interaction between learning strategy and academic ability on the learning results can be seen in Table 9.

Table 9: The results of the LSD test on the effect of the interaction between Learning Strategies and Academic Ability on the Critical Thinking Skills

Class	Academic ability	Group	X critical thinking	Y critical thinking	Difference	Critical thinking COR	Lsd Notation
1 = control	1 = Low	1	0.70	0.98	0.28	1.03	a
1 = control	2 = high	2	1.25	2.66	1.42	2.62	b
2 = experiments	1 = Low	3	0.77	2,69	1.92	2.72	b
2 = experiments	2 = high	4	1.31	3.63	2,32	3.57	c

The table shows that PDEODE learning strategy in the students having high academic ability is best in empowering students' critical thinking skills. Meanwhile, the critical thinking skills of the students having low academic ability in the experimental class (PDEODE learning strategy) was not significantly different from the students having high academic ability in the control class.

3.5 Interpretation

The results of the analysis show that the PDEODE learning strategy has a huge potential in empowering students' critical thinking skills. The potential is certainly related to the syntax of PDEODE learning strategy which connects the students' real life experiences with the learning materials being taught. The process of the demonstration using worksheets of PDEODE starts with the students predicting about the problems given and try to provide an explanation of the underlying hypotheses they make. The students work in small groups to discuss the hypothesis related to the problem to be solved. After that, the teacher and the students in each group clarify their understanding through discussion. Before making an observation, the teacher provides information to students about what to observe and how to make observations. Teachers and students observe something relevant. This will raise the questions on students about what they see, what will happen, and why it can happen. Students try to answer the questions by exploring knowledge deductively. After making observations and demonstrations, students prove their hypothesis with actual observations. Students can

correct their misconception with a newer concept that they obtain. At this stage, the students get the information by analysing, comprising, conflicting, and criticizing. It shows a different thing from what they do during the discussions in small groups. All the disagreements between observations and hypotheses can be synchronized at the final stage (Explain II).

As expressed by costumers (2008) that this learning strategy is based on the constructivism view that new knowledge is built from the existing knowledge to construct knowledge from the natural phenomena around us. Based on the constructivist perspectives, learning is not purely a stimulus-response phenomenon as conceptualized by the behaviorists, but learning is a process that requires self-regulation and the development of conceptual structures through reflection and abstraction. Real activities carried out in the experiment provide a learning experience that can help reflection and make the relationship between the real world activities and the conceptual knowledge are expected to develop wider and deeper. This suggests that PDEODE learning strategy, which was based on real-world activity, has the potential to broaden and deepen conceptual and procedural knowledge that can empower the development of students' critical thinking skills.

The results of the analysis in this research showed that PDEODE learning strategy can empower students' critical thinking skills. PDEODE learning strategy has an effect on students' critical thinking skills 71.43% higher than that of the conventional learning strategy. This is consistent with the findings of Kolari et al (2005) that PDEODE learning strategy can help students learn better and build their capability and confidence to evaluate their knowledge. In PDEODE learning, the students more actively construct their own knowledge.

Academic ability is one of the internal factors that affect students' learning results. The results of this research found that different academic abilities will also result in different critical thinking skills. This is in line with the findings of Hasan (2012) that on the average 86% of student's academic achievement is influenced by their academic ability, especially the high-order thinking skills. Students having good academic skills will demonstrate good academic achievement as well; conversely, students having poor academic skills that will demonstrate poor academic achievement as well. In addition, it was revealed that the critical thinking skills had greater effective contribution on cognitive learning results.

This research found that the interaction of learning strategy and academic ability had a significant effect on students' critical thinking skills. PDEODE learning strategy which is implemented to the students having high academic ability is best in

empowering students' critical thinking skills. The students having high academic ability are able to easily and actively follow any of the learning steps. The results of this research also show that the empowerment of the critical thinking skills of the students having low academic ability in PDEODE learning is as good as those of the students having high academic ability in the conventional learning. This shows that PDEODE learning strategy is basically able to facilitate the students having low academic ability in empowering their critical thinking skills. This is because in PDEODE learning strategy the students can communicate with the other students to discuss their opinions and conflicts, to make predictions, interpretation and explanation in constructing their knowledge, and can fix their misconception through discussion and demonstration (Kolari and Ranne, 2003). PDEODE learning also allows collaborative learning patterns to occur in that the students having high and low academic ability can interact with each other. This was supported with the research findings by Kolari et al (2005) showing that the implementation of PDEODE learning strategy can increase students' motivation. Students are more active in interacting with the members of their study groups. The students having low academic ability can overcome their difficulties in learning with the collaboration patterns with their group members during the discussion stage. The discussion stage which is conducted twice, before and after the observation, provides more space for the students to exchange their ideas, build their knowledge, reduce their misconceptions, and evaluate their knowledge.

The results of this research were interesting because although the high and low academic ability was significantly different on the students' critical thinking skills, it was found that the increase of the critical thinking skills of the students having low academic ability was bigger than that of the students having high academic ability. The increase of the students having high academic ability was 181.96%, while the increase of the students having low academic ability was 260.54%. This shows that students having low academic ability have more development than the students having high academic ability. This is because the students having low academic ability made efforts to know and understand the problems and questions in the worksheet during the *Predict* stage to be discussed at a later stage with their heterogeneous group. Such activities can stimulate the formation of the students' thinking skills. According to Lie (2008) Slavin (2010), discussion and argumentation with each other will bring expansion and cognitive conflict in students, as a result, the students will be accustomed to thinking activity. Furthermore, Slavin (2010) revealed that heterogeneous group will advantageous for both the students having high academic ability and the students having low academic ability.

The results of this research are similar to the findings of Effendi's research (2012) showing that in RT learning strategy the learning results of the students having high academic ability were 1.05% lower than those of the students having low academic ability. This suggests that the teacher's roles in managing the learning activity are very essential, so that the teachers' ability to understand, innovate, and implement the syntax of the learning strategies is the key to successful learning. Teachers who can describe the syntax and innovate the learning strategy will be able to make the learning activity more interesting. Therefore it will improve the quality of the students' biology learning results

PDEODE learning strategy emphasizes the students to play an active role in the learning process where students discover and construct their own knowledge. The problems given to students and the experiments conducted by the students are associated with the students' environment so that students can search for the solutions in accordance with their cognitive development. The students have the freedom to investigate and solve the problems either individually or cooperatively with the other students. Such Student-Centered Learning can help the students to learn better. The students can develop their capability and confidence to evaluate their knowledge.

PDEODE learning strategy provides the students the opportunity to express their prior knowledge regarding the learning materials, and it provides the opportunity to cooperate with the other students during the discussion session. The exchange of ideas among the students can lead to a conceptual change in the students' knowledge. The same treatment and opportunities as well as the patterns of collaborative learning given to the students with high and low academic ability will give a greater effect on the low academic ability students to improve their critical thinking skills.

The results of this research show that PDEODE learning strategy has several advantages compared to the conventional learning strategy implemented in schools: 1) the students are active in the learning process, 2) the students construct their knowledge from the existing phenomena, 3) the students' motivation and creativity are high , 4) provide the opportunity for discussion both among the students having different academic abilities and between the students and teachers, 5) It explores the students' prior knowledge, 6) It stimulates students' curiosity toward a problem, and 7) the learning activity is real and can be done outside the classrooms such as in the laboratory or in the surrounding environment. While the disadvantages of this learning strategy are is: 1) learning activity requires a considerable amount of time, 2) the learning material is difficult to be completely presented.

4. Suggestions

1. It is expected that the PDEODE learning strategy should be implemented in the biology learning to empower students' critical thinking skills.
2. Since PDEODE learning strategy requires a considerable amount of time, the time allocation of lesson should be taken into account, especially for the experiment, demonstration, and the observation activities.
3. The learning material is sometimes difficult to be completely delivered. Therefore before implementing PDEODE learning strategy, teachers are expected to analyse the learning material in advance.

5. Conclusion

1. There is a difference in the critical thinking skills of the students taught by using PDEODE learning strategy and those taught by using a conventional learning strategy. The corrected mean score of the experimental class was 62.40 while the corrected mean score of the control class was 36.40. It shows that PDEODE learning strategy has a greater effect on the students' learning results that is 71.43 % compared to the conventional learning strategy.
2. There is a difference in the critical thinking skills of the students having different academic abilities. The corrected mean score of the students having high academic ability was 61.80 while the corrected mean score of the students having low academic ability was 37.00. It shows that high academic ability gives bigger effect on students' learning results, that is, 67.03 % compared to the low academic ability.
3. There is a difference in the students' critical thinking skills due to the interaction between PDEODE learning strategy and academic ability. The PDEODE learning strategy on students having high academic ability is best in empowering students' critical thinking skills. The critical thinking skills of the students having low academic ability in the experimental class (PDEODE learning strategy) is not significantly different from those of the students having high academic ability in the control class. The critical thinking skills of students having low academic ability PDEODE learning strategy were similar with the critical thinking skills of the students having high academic ability in the conventional class. It shows that PDEODE was basically able to empower the critical thinking skills of the students having low academic ability

4. On the PDEODE learning strategy, the increase in the critical thinking skills of the students having low academic ability was bigger than that of the students having high academic ability. The increase of the students having high academic ability was 181.96%, while the increase of the students having low academic ability was 260.54%. The same treatment and opportunities given to the students having low academic ability as well as the patterns of collaborative learning among the students having high and low academic ability in PDEODE learning strategy gave a greater effect in increasing the critical thinking skills of the students having low academic ability.

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