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DISCOVERING LEARNING STRATEGY TO INCREASE METACOGNITIVE KNOWLEDGE ON BIOLOGY LEARNING IN SECONDARY SCHOOL

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ABSTRACT

The study is aimed at finding an effective learning strategy that can increase metacognitive knowledge. Metacognitive knowledge is a standard that based on 2016-revised edition of 2013 curriculum needs to be achieved by every graduate in all level of education in Indonesia. The study is conducted in three different schools and engages 207 students, which then divided into six groups. The groups are students who study under mind mapping strategy, concept mapping, reciprocal teaching using summary notes, reciprocal teaching using mind mapping, problem-based learning, and investigation group. The results showed that those studying under problem-based learning strategy spent a significantly higher numbers in metacognitive knowledge in biology learning and followed by students who study under reciprocal teaching using mind mapping. According to the finding, it is expected that teachers of Biology will practice problem-based learning strategy in their classroom in order to increase the Metacognitive knowledge.

Keywords: metacognitive knowledge; group investigation; reciprocal teaching; mind map; concept map; problem-based learning

INTRODUCTION

Metacognitive knowledge is an important component in the accomplishment of Indonesian graduation standard in 2013 curriculum. According to the decree of Minister of Education and Culture Number 20 in 2016 about the graduation standard, it states that in the high school level a graduate should be equipped with factual, conceptual, procedural, and metacognitive knowledge in terms of technical, specific, detailed and complex level which relates to science, technology, arts, culture and humanities.

Metacognitive knowledge is a new dimension in Indonesian graduation standard. The 2006 curriculum covers factual, conceptual and procedural knowledge which made the ability of higher order thinking of Indonesian students is quite poor.

One of the indicators can be seen in science literacy. According to Program for International Assessment (PISA) in 2012, the Indonesian students' science literacy ranked 64^{th} from 65 countries and its score below World average. The science literacy score of Indonesian students is the lowest of all South East Asian Countries, such as Malaysia (ranked 52), Singapore (ranked 2), Vietnam (ranked 17), and Thailand (ranked 50). Metacognitive has been included in the graduation standard so that it will be able to increase the students' higher order thinking. It is in accordance with Livingston (1997:3) who states that metacognition refers to higher order thinking which involves active control over the cognitive processes engaged in learning.

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The definition of metacognitive knowledge according to the decree of Minister of Education and Culture Number 20 in 2016 is knowledge about one's cognitive strengths or weaknesses and how to utilize it in learning technical, detailed, specific, complex, contextual and conditional knowledge about science, technology, arts, and culture which relates to the society and environment, nation and state, regional and international. The definition states that metacognitive knowledge is *self regulated process*. Relationship between self regulated and metacognitive knowledge was explained by Artelt, Weinert, & Handel, (2013:162) reading or mathematical literacy. Metacognition is a central component in the process of self-regulated learning. It is defined as cognition about cognition and encompasses two components: the knowledge component and the regulation component.

Metacognitive knowledge of tasks operates when the nature of task forces us to think about how we will manage (Jayapraba & Kanmani, 1998:48). Rompayom, Tambunchong, Wongyounoi, & Dechsri (2010:213) divides knowledge into three categories, namely knowledge about your own self or individuals (declarative knowledge), knowledge of the tasks or activities (procedural knowledge) and knowledge of learning strategies (conditional knowledge). Declarative knowledge refers to the knowledge that learners have about the information of resources needed for undertaking the given tasks. Procedural knowledge refers to knowledge of beliefs about us about given task; an individual's self-perceptions of one's capacity of how to do something. Conditional knowledge refers to knowledge concerning when and why to use strategies to solve problems.

To increase their metacognitive abilities, students need to possess and be aware of three kinds of content knowledge: declarative, procedural, and conditional. This notion of three kinds of knowledge applies to learning strategies (Pierce, 2003). Some of research recommended some strategies to increase metacognitive knowledge.

Pintrich (2016:223) recommends comprehensive reading competence which is really effective as metacognitive knowledge learning strategy, especially in a group discussion. According to Doolittle, Hicks, Triplett, Young, & Tech (2006:115), comprehensive reading can be done by using reciprocal teaching. Choo, Eng, & Ahmad (2011:142) states that reciprocal teaching is based on active socialization, wherein the knowledge constructed from the text is negotiated within discourse communities through both teacher student and student-student interactions. Furthermore, there are four steps in reciprocal teaching strategy (Garderen, 2004:26). They are summarizing, clarifying, integrating, and elaborating. Furthermore, Agoro, (2013:5) have developed reciprocal teaching as a strategy which consists of three main components: (a) the teaching and learning of specific concept and the strategies (b) the dialogue between an instructor and students about why, when, and where to use the strategies and (c) the appropriating of the role of the instructor by the students, students begin to model the strategy for other students. Thus, the goals of reciprocal teaching are for students to learn the strategies, learn how and when to use the strategies and become self-regulated in the use of these strategies.

Novak & Cañas, (2008:1) suggests concept map as metacognitive learning strategy in science teaching. Concept mapping is a useful tool for helping students learn about concept that is built on a perceived regularity in events or objects, or records of events or objects, designated by a symbolic label and word to describe the structure of concept map. Concept mapping helps students in improving metacognitive knowledge as stated by Vanides, Yin, Tomita, Ruiz-Primo, (2005:28) that concept maps give students an opportunity to: (1) think about the connections between the science terms being learned, (2) organize their thoughts and visualize the relationships between key concepts in a systematic way, and (3) reflect on their understanding.

Adodo (2013:170) also stated that concept mapping is useful as Self Regulating Learning (SLR) media. SLR is a part of metacognitive strategy. Self-regulating occurs when concept mapping provides students an opportunity to explore relationships between ideas and elements of an argument and to generate solutions to problems (Buzan, 2012:8). Additionally Evrekli, Balim, & Inel (2009:2279) presented that mind map can facilitate to recall knowledge and conceptions and the interrelations set between them.

Another learning method that is related to metacognitive is problem-based learning (PBL). PBL has used widely, because it has some advantages, PBL improved argument skill of students (Pritasari, Dwiastuti, & Probosari, 2015:154), creative thinking (Hartini, Kusdiwelirawan, & Fitriana, 2014:60), critical thinking (Fakhriah, 2013:94), and PBL strategy that enables student to solve a problem that potentially increases metacognitive knowledge (Pintrich, 2016:224). A study by Tosun & Senocak (2013:66-67) shows that after the implementation of problem-based learning the three metacognitive knowledge indicators, i.e. declarative, procedural, and conditional knowledge, on high school-teacher candidates increase significantly. On the other hand, the metacognitive knowledge on elementary school-teacher candidates both before and after PBL implementation shows no difference. Problem-based learning increases metacognitive knowledge because students need to equip themselves with sufficient information in order to solve the problem. Problem-based learning requires self-directed learning skill. When individuals try to be self-directed learners, metacognitive thinking become important.

In Indonesia, Biology learning mostly applies Group Investigation approach. The approach is used since Biology content requires an investigation activity whether direct investigation by observation either on the field or laboratory, or indirect investigation by finding literatures on research that has been conducted by scholars. Group investigation is a compulsory menu in Biology. Hence, when some approaches need to be selected it is necessary to include group investigation as one them.

This study is aimed at finding several learning strategies that will be able to increase the students' metacognitive knowledge. The strategies are concept mapping, reciprocal teaching, problem-based learning and group investigation learning

METHODS

The research uses a quasi-experiment. A quasi-experimental design can be seen in the Table 1.

Table 1. A quasi-experimental Research Design

1:	O_1	X_1	O_2
2:	O_1	X_2	O_2
3:	O_1	X_3	O_2
4:	O_1	X_4	O_2
5:	O_1	X_5	O_2
6:	O_1	X_6	O_2

note:
X1 = scientific approach with mind map
X2 = scientific approach with concept map
X3 = Reciprocal Teaching with summary note
X4 = Reciprocal Teaching with mind map
X5 = Problem-based learning
X6 = Group Investigation
O_1 = Pre test
O_2 = Post test

The research engages three senior high schools in Jakarta and South Tangerang. The target population is students in grade 10 of Science program. The research sample uses simple random sampling, which based on group of subject and the participants are 207 students.

The data collected from learning outcomes on pre and post test. The test items are created according to basic competence of 2013 curriculum. Metacognitive inquiries are developed from Rampoyam et al. (2010). There are 16 inquiries assigned and arranged based on the difficulty levels. 6.25% belongs to easy, 37.5% belongs to moderate and 56.25% belongs to difficult. Table 3 shows the test items framework and the inquiry examples.

The data is analyzed on one way ANOVA. When it is known that the data has normal distribution, it is then tested using Shapiro-Wilk normality test (pre test = 0.97 Sig 0.00; post test = 0.99 Sig 0.078). Then, the post-hoc test is using Tukey test. Data analysis in ANOVA and Tukey's Post Hoc Test is used to find the distinction between one experimental group and the other group. Data analysis is conducted by SPSS program. Furthermore, the data is analyzed in Normalized Learning Gain (Meltzer, 2002:7) and according to (Hake, 1999:1) the category of the learning improvement belongs to high, medium and low. Normalized learning gain analysis and its category is used to find the improvement in cognitive knowledge both before and after the learning process. The formula of Normalized Learning Gain is:

$$gain = \frac{posttest\ score - pretest\ score}{maximum\ possible\ score - pretest\ score}$$

- High-g courses as those with (<g>) > 0.7
- Medium-g courses as those with 0.7 > (<g>) > 0.3
- Low-g courses as those with (<g>) < 0.3.

RESULT AND DISCUSSION

Descriptively the result of pre and post test can be seen in Figure 1. It shows that the average score on the pre test of X1 and X2 groups and the other groups has quite ample difference in the average score i.e. 20 point. Whereas on the post test, the score difference of the inter-group is not more than 10 point. Figure 1 also describes that X5 group show the highest improvement among the other groups. Even though X5 group has the lowest score in the pre test, its post test is slightly increasing. Aside from that, Figure 1 shows that

Table 2. Population, Sample, and Number of Samples

	School	Number of Science Program in 10th Grade Class Program	Sample	
			Number of student in Class	
A	South Jakarta School I	3	Science Class II	31
			Science Class III	32
B	South Tangerang School	5	Science Class II	36
			Science Class III	36
C	South Jakarta School II	4	Science Class I	36
			Science Class IV	36
	Sum	12		207

Table 3. The test items framework and the inquiry examples

Basic competence	Inquiry Indicator	Cognitive Aspect	Inquiry illustration
Implementing an understanding about the virus which relates to its features, replication, and roles in community health aspect.	Explaining the reason and objective of creating virus history	C4	Why is there a chronology of virus history in Biology textbook? (Choose the best answer!) 1. Virus is historical heritage 2. Virus is science 3. Virus causes plague 4. Respect the scholars who have great rule 5. Virus is the simplest form or organism Metacognitive knowledge inquiries 1. What do you need to know earlier to be able to answer inquiries properly? 2. How do you find the solution which is like the previous inquiry? 3. When will you answer as in part (b)? Why do you use such method?
	Determining how to group the virus properly	C5	
	Differentiating virus reproduction in lytic and lysogenic	C2	
	Organizing the best way to prevent virus	C3	

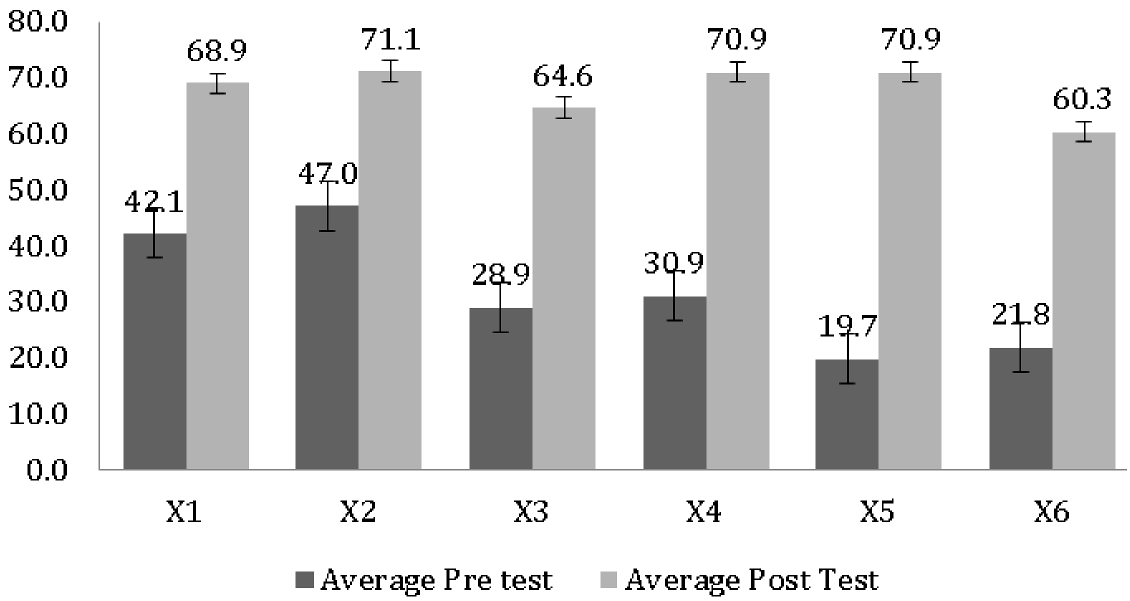

Figure 1. Average Pre test and Post Test

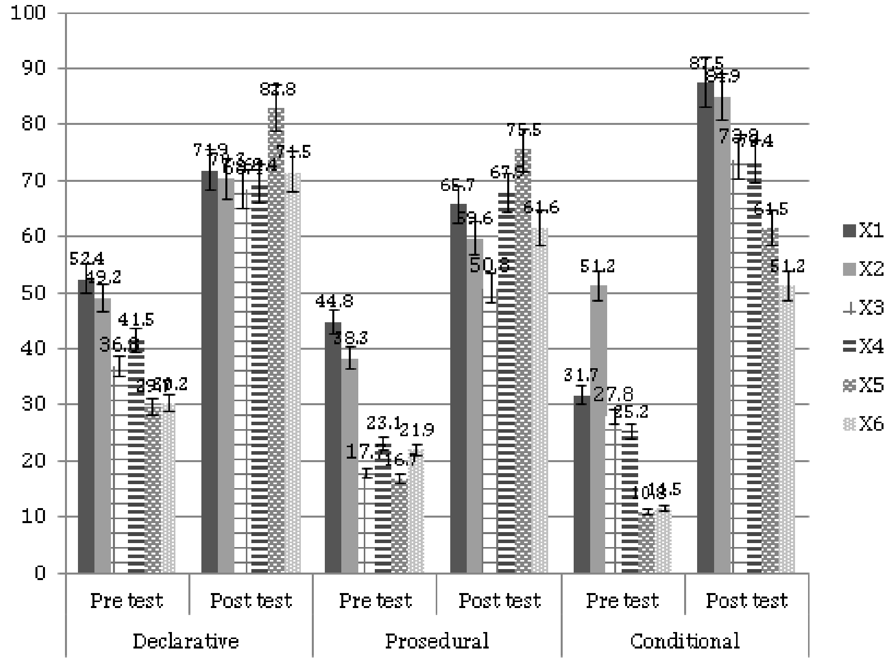

Figure 2. Performance of Metacognitive Knowledge

X2 group has the lowest improvement.

According to the aspect details of metacognitive knowledge, the result of pre test and post test has indicated in Figure 2. The figure shows that there is no similar pattern among groups. Each group has its own prominence. X1, X2, X3, and X4 groups have an outstanding aspect in conditional knowledge. While X5 and X6 groups have an excellent aspect in declarative knowledge. Moreover, these two groups also have a prominent aspect in procedural knowledge compare to the other groups.

Students who participate in the study come from different schools; however, each school has one similarity, i.e. it has been the pilot project for 2013 curriculum implementation. A test on each school-initial competency is required to find the difference on the students-initial competence in the three schools and six distinct grades. The result of ANOVA test shows significant difference in the inter-group (F= 35.18 Sig. 0.00), whereas the Tukey's post-hoc test on Table 4 exposes the position of the difference in the inter-group. Table 4 describes that the difference of the initial competence occur both in the inter-school and inter-group. For instance in B and C school, there is some difference on the initial competence. X1 and X2 groups have significant difference though they are from the same school (A school). The similar situation happens on X3 and X4 groups which come from B school and also X5 and X6 groups from C school.

Based on the result of pre test on Table 4, the post hoc test on finding the most effective learning strategy cannot use the data from the post test. The data from the post test has some bias due to the impact of the initial competence of the students which is different though they are in the same group. To avert the bias, gain (the pre test and post test excess) is applied.

The result of inter-group different test by applying gain shows significant difference in the inter-group (ANOVA ONE WAY, F=18.15 Sig. 0.00). Table 4 shows Tukey's post hoc test for metacognitive knowledge's gain.

Table 5 exposes the significant difference in the groups which use various learning strategies. According to Tukey's post hoc test, it is known that significant difference occur in X1-X4, X1-X5, X1-X6, X2-X4, X2-X5, X2-X6, X3-X5, dan X5-X6 groups. The result of N-Gain test can be seen in Table 6. According to Table 6, X4 and X5 groups have the highest gain increase with the excess more than 10 point of the other groups. Whereas the other groups, i.e. X1, X2, X3, and X6 have the excess of the inter-group around 1 point. According to low, medium and high group distribution, Table 6 shows that in X5 group the improvement of metacognitive knowledge is distributed in medium and high group. It means that 100% students belong to medium and high category in the improvement of their metacognitive knowledge. Moreover, it also explains the effective learning strategy used to increase the students' metacognitive knowledge. In X4 and X6 groups have few students who belong to low

Table 4. p value of Metacognitive knowledge Pre-Test in Tukey Test

School	Group	A: X_1	A: X_2	B: X_3	B: X_4	C: X_5	C: X_6
A	X_1		0.44	0.00	0.00	0.00	0.00
	X_2			0.00	0.00	0.00	0.00
B	X_3				0.97	0.005	0.00
	X_4					0.05	0.004
C	X_5						0.96
	X_6						

Table 5. Significance Score based on ANOVA and Tukey's test Metacognitive knowledge's Gain

	X_1	X_2	X_3	X_4	X_5	X_6
X_1		0.96	0.32	0.00	0.00	0.00
X_2			0.04	0.00	0.00	0.00
X_3				0.12	0.00	0.68
X_4					0.06	0.89
X_5						0.00
X_6						

Table 6. The Result of N-Gain Test's Average and Distribution According to N-Gain Attainment Category.

Group	n-Gain							
	Average	Criteria						Sum (n)
		Low		Medium		High		
		People (n)	Percentage (%)	People (n)	Percentage (%)	People (n)	Percentage (%)	
X_1	0.45	6	19.4	20	64.5	5	16.1	31
X_2	0.46	8	25.0	18	56.3	6	18.7	32
X_3	0.47	6	16.7	27	75.0	3	8.3	36
X_4	0.58	2	5.6	28	77.8	6	16.7	36
X_5	0.65	0	0	24	66.7	12	33.3	36
X_6	0.50	3	8.3	29	80.6	4	11.1	36

on the N-Gain improvement category. It means that more than 90% students show medium and high improvement on metacognitive knowledge even though X6 group, according to N-Gain average result, has lower score than X4. According to Tukey test (Table 5) X4, X5 and X6 groups are hardly different. On the other hand, in X3 group more than 80% students show improvement in their metacognitive knowledge. It means that the learning strategy applied in this group is categorized as effective to increase students' metacognitive knowledge as the one used in X4 and X5 groups.This is indicated by the absence of a significant difference between the groups X3 with X4 and X6 on Tukey's test (Table 5).

The most effective strategies to increase students' metacognitive knowledge are problem-based learning, reciprocal teaching and group investigation. Reciprocal teaching with mind mapping is more effective than with the usual note taking. Problem-based learning is most effective strategy in improving metacognitive knowledge since the strategy has several steps that correlate with metacognitive knowledge. Rahayu & Azizah (2012:167) stated that there are three phases and seven syntaxes of problem-based learning about metacognitive knowledge. Table 7 explains the relation of metacognitive knowledge, syntax and problem-based learning phases.

Another effective learning strategy is reciprocal teaching. Reciprocal teaching focuses neither on the discovery activity nor the knowled-

Table 7. The relation of metacognitive knowledge and problem-based learning syntax

Metacognitive knowledge	Syntax of Problem-based learning	Phase of Problem-based learning
Declarative knowledge	Exploring students' prior knowledge by having students to do Self-Understanding Assessment Question Asking students to collect all information related to the formulation of the problem in groups	Organize the student for study
Procedural knowledge	Guiding students to observe/practice Guiding students to do analysis and make conclusion to find explanations and solutions to the problem	Assist independent and group investigation
Declarative knowledge	Guiding students who have acquired the knowledge revealed from observations and analysis by asking the students do the Self-Understanding Assessment Questions and application question contained in the worksheet. Guiding students to reflect or evaluate the learning process they use Guiding students to conclude the learning outcomes (declarative,	Analyze and evaluate the problem-solving process

Source: Rahayu & Azizah (2012: 67)

ge construction. It focuses more on the reflection activities, i.e. questioning, clarifying, summarizing and predicting (Cooper & Greive, 2009:45). Agoro & Akinsola (2013:5) said that Reciprocal Teaching consists of the main component that describe metacognitive strategy. The component is the dialogue between an instructor and students where the instructor models why, when, and where to use the strategies. The practice of reciprocal teaching with mind mapping optimizes the students' metacognitive knowledge improvement. The application of mind mapping makes the information distributed on students' mind more structured as stated by Buzan (2012:8) mind map puts a new perspective on things by allowing you to see all the relevant issues and analyses choices in light of the big picture. Mind map also becomes easier to integrate new knowledge and organize information logically as you aren't tied to a rigid structure.

Furthermore, group investigation learning is the other effective strategy in improving metacognitive knowledge. Group investigation learning is discovery learning that gives students opportunities to construct knowledge in a group. Sharan & Sharan (1989:17) explained that in group investigation students take an active part in planning what they will study and how. All group members help plan how to research their topic. The discovery activity and knowledge construction in group investigation learning enable students to actively control their cognitive activities. The ability in utilizing cognitive activity control makes students' academic performance and achievement become higher (Jayapraba & Kanmani, 1998:48).

CONCLUSION

Problem based learning is one of the most effective strategies in improving metacognitive knowledge. Another strategy is reciprocal teaching with mind mapping. Meanwhile a group investigation is a strategy that is mostly practiced by teachers of Biology as it is literally effective to increase metacognitive knowledge.

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