Journal for the Education of Gifted Young Scientists, 8(2), 651-665, June 2020
e-ISSN: 2149- 360X
jegys.org

youngwisepub.com

Research Article

Investigating the effects of problem-solving method and cognitive flexibility on improving university students' metacognitive skills

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Article Info

Received: 28 November 2019
Revised: 11 March 2020
Accepted: 16 March 2020
Available online: 15 June 2020

Keywords:
Cognitive flexibility level
Metacognitive skills
Problem solving method

2149-360X/

Abstract

This study was aimed to investigate the effects of the problem-solving method on university students' metacognitive skills and cognitive flexibility levels. The research was modelled in a semi-experimental pattern, with experiment-control groups. According to the cluster sampling technique, 144 pre-service teachers who attended the Elementary Teacher School program in the spring semester of 2018-2019 had been determined as participants in Indonesia. Cognitive Flexibility Inventory (CFI) and Metacognitive Awareness Inventory (MAI) were used as data collection tools. An Independent Sample t-Test and descriptive statistics techniques were used in the analysis of the data. The discussion method, which is used more in university education, was employed in the control group, while the problem-solving method was employed in the experimental group. As a result of the research, it was found that there was a significant difference in the metacognitive skill levels of students with high cognitive flexibility when compared to those with low cognitive flexibility. This differentiation is in favor of students with a high cognitive level. Furthermore, a significant differentiation was observed between the metacognitive skill scores of the two groups where the discussion and problem-solving methods were applied. It was seen that this differentiation was in favor of the group with the problem-solving method. This study therefore recommends that instructional adaptations should be made to increase pre-service teachers' cognitive flexibility. Also, the problem-solving method can be used for the development of metacognitive skills. Thus, they can provide experiential knowledge during the university education process, in order to develop these two important features.

To cite this article:
Idawati., Setyosari, P., Kuswandi, D., & Ulfa, S. (2020). Investigating the Effects of Problem-Solving Method and Cognitive Flexibility in Improving University Students' Metacognitive. *Journal for the Education of Gifted Young Scientists*, *8*(2), 651-665. DOI: http://dx.doi.org/10.17478/jegys.652212

Introduction

Metacognitive skills are undoubtedly one of the most essential abilities that 21st century learners must incorporate within themselves for the sake of overcoming challenges such as problem solving, decision making, assumption analysing, and science inquiry (Greenstein, 2012). In line with that statement, the main purpose of learning and teaching is to prepare our learners to conquer the obstacles of their era whilst also contributing positively for the environment. Therefore, their metacognitive ability is one of the most compulsory skills to be developed, and one way to do so is by giving challenges for the learners (Delors, 2013; Corebima, 2010). Metacognitive skills have been acknowledged since 1970 in the field of cognitive psychology. The term metacognitive was initially used by Flavel on 1976, in which it was defined as one's awareness on their thinking process (Eggen and Khaucak, 2012).

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On the other hand, Anderson & Krathwohl (2010) stated that metacognitive is the philosophy of cognition in general and the awareness of the knowledge of cognition itself. It was further explained by Fazey, et al. (2007) and Spellman (2015) that metacognitive is the individual's ability to control their own minds which may affect the growths of their thinking skills. Metacognitive is the knowledge, the ability to understand, control, and aid one's thinking process (Matlin, 2009; Anderson & Krathwol, 2010). Seeing the critical effects of metacognitive skills to humankind's actions, it is then argued by Avargil, et al. (2018) that metacognition, a crucial component in teaching and learning, must be applied as a part of science curriculum starting as early as kindergarten and continued out to college and university levels.

However, the current phenomena humankind confronts is that teachers today lack in possessing their attention on developing students' metacognitive skills. Teachers are limited to only deliver the introduction of concepts to learners through conventional methods which do not stimulate learners to think further and more critically, which could lead to improving their metacognitive skill. According to Rosa (2015), Indonesian teachers should consider integrate more activities which would enrich students' metacognitive skills within learning and teaching. In addition, 60% university students are unable to analyze nor comprehend topics in science courses due to their lack of thinking skill and inability to reflect on their learning process- in other words, students are not competent in their metacognitive skills (Paidi, 2008). When integrated within learning and teaching activities, metacognitive skill pushes learners to be independent in solving problems which require strategy and thinking process. Tortop (2015) claimed that students' independence must be sustained gradually and consistently. Hence, the development of metacognitive skills on learners must continually be carried out from early educational level (pre-school) up to higher academic level (universities). Metacognitive skills also enable learners to recognize problems and investigating ways to invent the solution, which can eventually become a motivation for the learners throughout the learning process (Corebima, 2009; Jonassen, 2011; Hui, 2016; Coşkun, 2010). While this may be true, metacognitive skill can also be utilized by learners to fathom on their own abilities to improve themselves (Spada, 2010; Dawson, 2016).Those theories suggest to implement metacognitive skill improvement in early age and continue steadily up until university level, in which in reality many still lack comprehension skill.

Several studies discovered novel innovations in improving science students' metacognitive skills and agreed that the use of conventional methods such as lecturing and discussion method is out-of-date (Akben, 2018; Dang et al. 2018; Gezer-Templeton et al, 2017; Safari, et al 2016). Gezer-Templeton et al. (2017) aimed to enhance the students' practice of thinking and implemented the use of exam wrappers which the students found to be improving their self-reported study habits. Akben (2018) believed that improving students' problem skills in science education must always be given special attention and integrating the use of problem-posing approach can successfully improve students' metacognitive awareness. In addition, Safari et al. (2016) stated that metacognitive strategies are highly recommended to be taught to students as metacognitive instruction has positive effects on students' problem solving skills and is required to enhance their academic achievements. Metacognitive skills help students to transform their notions into written and verbal information, as well as improving their self-evaluation skills (Dang et al. 2018). In agreement with the research conducted by Suet al. (2016), students' metacognitive skill is one approach in improving the quality of science lessons in higher education. All of those studies agreed that the different methods being implemented, as long as they aim to enhance the students; metacognitive skills, would give great impact on students. The newer the instructional materials and strategies being used, the more improved the students' thinking skills would be. Thus, the integration of metacognitive skills can greatly support the success rate of problem-solving activities to shape the correct introductory knowledge on science concepts.

In order to continue promoting metacognitive skills to be embedded within lessons, the proper learning method which can trigger students to be actively involved during learning activities is highly required. This will help spark interests in the students' minds to think beyond the boundaries when they solve problems (Reigeluth & Carr, 2009). Teachers therefore plays an important role in selecting the most suitable method as according to the learners' characteristics, materials, as well as learning outcomes. One of the most appropriate learning methods in developing students' metacognitive skills is problem solving method. The stages composed within problem solving method involves thinking process in investigating solutions which helps develop metacognitive skills faster than implementing conventional methods which do not demand learners to become actively participate (Ali, 2010). According to Kim & Hannfin (2011), problem solving can be defined as an exploratory process through determined steps which aimed to focus on the activities within the process of solving the problems. This is done by interactions using various devices and other sources. David (2019), stated that problem solving method is the goal oriented steps that one takes in order to solve a problem. He believed that despite its complexity in analyzing a student's skill. Hence, problem solving

method is suitable in promoting metacognitive skills through its steps which leads to solution-finding and also offers thinking practise, which opens the opportunity for learners to measure their ability while also selecting the most fitted strategy in solving problems which can elevate one's cognitive levels. Polya (2004) distinguished the steps in problem solving method as the following: (1) understanding the problem; (2) devising plan for problem solving; (3) implementing the plan and (4) reflecting.

One of the most crucial factors which affect the success rate of a learning method in achieving learning outcomes is the condition. Learning conditions must be associated with the learning method. Condition, according to Degeng (2013) is a factor which can impact on the learning methods in improving the learning outcomes and it cannot be manipulated. Learning conditions include the field of study's components, the learners' characteristics, as well as their learning objectives. A learning condition which supports and promotes the metacognitive skills' developments is widely known as the students' cognitive flexibility. Cognitive flexibility is immensely vital to be integrated within 21st century learning, along with various innovations and sudden changes on all aspects of learning and teaching activities, especially on the use of latest methods for learners. Not restricted to also learning methods which require instant thinking process to comprehend concepts, theories, principles, and problem solving in each subject which creates a complex content and different situation which greatly needs cognitive flexibility. Cognitive flexibility needs to establish individual's thinking patterns into the appropriate behaviours as accordance to the faced situation and condition (Syah, 2013). Cole, Duncan, & Blaye (2014) also discovered that today's improvement in reading and obtaining information demands a high level of cognitive flexibility for one to be able to read and filter information. Other studies claimed that there is a significant relationship between the flexibility cognitive levels of the students with their behaviours and attitude in selecting the most proper strategy in solving learning problems (Cartwritght, 2008; Cartwright, 2010; Onen & Canan, 2014). Hence, there is a relation between problem solving method with the cognitive flexibility in increasing the level of metacognitive skills which will affect the learning outcomes' quality. Degeng (2013) added learning outcomes is all effects which can be seen as indicators of a score by the learning method implementation which occured during the learning conditions. Those results show problem solving as part of improvement on metacognitive skill, either cognitive flexibility.

As stated by Bilgin (2009), the relationship of cognitive flexibility and metacognitive skills can be seen as something positive, as cognitive flexibility tends to push learners into behaving more appropriately during the lessons. Gnaedinger, et al. (2016) also confirmed that a high level of cognitive flexibility is perpendicular to metacognitive skills such as the thinking ability to grasp the contents' meanings and their skills in implementing different strategies effectively in a learning and teaching activity. Learners with high level of cognitive flexibility tends to understand various topics faster due to their ability to adapt their cognitive structures easily as according to the classroom problems. On the contrary, those with a low cognitive flexibility level will experience a slow shift of thinking and undergo pressures in encountering new, unstructured condition (Elen, et al. 2011). Based on the previous studies, the implementation of both cognitive flexibility and metacognitive skills help improving students' thinking ability and enhance their learning experience. However, not all studies were proven to be successful as the methods failed to serve as a learning strategy. As an addition, research focusing on the impact of cognitive flexibility directly towards metacognitive skills with the subject of research being undergraduate students at university level is rarely carried out. The previous research only observed to what extent flexibility skills could impact on Language course-related materials. A gap in the investigation on science-course related material and learning methods had not yet been conducted. To add, a study investigating Indonesian undergraduate students' metacognitive skills when treated using problem solving methods had not yet been conducted. Hence, this research aimed to explore further on the gap analysis of the previous studies by focusing on the problem solving and cognitive flexibility in students' metacognitive skill developments for undergraduate students undertaking science course. Therefore, this research would like to focus discussion of about the:

- Is there a differentiation of teacher candidates' metacognitive skills according to their cognitive flexibility levels?
- Does the problem-solving method affect the development of pre-service teachers' metacognitive skills more than the discussion method?

Method

Research Design

This quantitative research used quasi-experimental design (Tuckman, 1999). It was implementedted because there was no possibility of determining random research sampling on the individuals, as they were already assigned in classes as

structured by the institutions' regulations or higher academic institute (Setyosari, 2016). Therefore, this research determined the research subject by using cluster random sampling, which uses the existing groups as the experimented and controlled groups. This research was held for 6 months, starting from June to December 2018. It was decided so by considering the amount of materials given and the steps in problem solving method to be adjusted to the learning and teaching activities throughout the semester. Questionnaires were then distributed to explore the differences on the students' metacognitive development levels. The research design can be seen in the following Table 1.

Table 1.
The Research Design

No	Research Design	This Research
1.	Research Model	Quasi-experimental design
2.	Research Participant	Cluster random sampling of 144 undergraduate students of a private university in East Java
3.	Data Collection	CFI & MAI Questionnaires
4.	Data Analysis	Independent Sample T-Test
5.	Instruments	Cognitive Flexibility Inventory (CFI)
		Metacognitive Awareness Inventory (MAI)
		Syllabus and Lesson Plans

The implementation consisted of the following steps: (1) identifying the flexibility of experimented and controlled groups by distributing cognitive flexibility questionnaires as adapted from Dennis & Vander (2010); (2) conducting learning and teaching activities by implementing problem solving method on experimented group and discussion method on the controlled group. Throughout the course, the experimented group did not involve the lecturer of Natural Science course but was taught directly by the researcher based on the planned problem-solving method as designed by the researcher as accordance to the data collection technique in this study. The controlled group, on the other hand, was taught by the lecturer of Natural Science course, implementing discussion method which had been used in the classroom by the lecturer as accordance to his lesson plans; (3) identifying the metacognitive skills of the experimented and controlled groups by distributing Schraw & Dennison (1994)'s questionnaire to investigate their metacognitive skills after completing the course. Then, data analysis and results were discussed.

Participants

The subjects of the research are students of a private university in East Java, Indonesia, whereas the samples of this research consist of 144 undergraduate students of Elementary School Teacher degree undertaking Natural Science course on their third semester. The students of four classes: A, C, E, F, are divided into two groups with 72 students each- one group. The experimented group which consisted of Class C and E is going to be taught using problem solving method, whereas the other controlled group which consisted of Class A and F will be taught using discussion method. The researchs samples details are as follows.

Table 2.
Description of Participants

Subject	Class	Students	Learning Method
Experimental group	C	36	Problem Solving Method
	E	36	
Control group	A	36	Discussion Method
	F	36	

Instruments

Cognitive Flexibility Instruments (CFI)

Cognitive Flexibility Inventory (CFI) was used to determine the students' cognitive flexibility level as adapted from Dennis & Vander (2010). This questionnaire consists of 20 statement items. The arrangement of this instrument is based on cognitive flexibility indicators, i.e. (1) the tendency to view difficult situations as something that can be controlled, (2) the ability to see or perceive several alternative explanations for life events and human behaviours and (3) the ability to produce several alternative solutions for difficult or uncommon situations. To see the high score or the tendency of students' cognitive flexibility, each statement has 5 answer choices, i.e.: (STS) Strongly Disagree graded score 1 (TS) Disagree graded score 2, (N) Neutral graded score 3, (S) Agree graded score 4 (SS) Strongly Agree graded

score 5. The instrument was reliable (Cronbach's alpha = 0,71) and valid (score of Corrected Item-Total Correlation is above of r-table).

Metacognitive Awareness Inventory (MAI)

MAI was used to measure the students' metacognitive skills, it was adapted from Schraw & Dennison (1994) which consists of 52 items with the statement based on metacognitive indicators: (1) declarative knowledge; (2) procedural knowledge; (3) conditional knowledge; (4) planning skills; (5) information processing skills; (6) self-control skills; (7) monitoring; and (8) evaluating skills. The 52 four-option questions are differentiated as according to the Likert scale, which is categorized into the following: (N) Never, with the score of 1; (SD) Seldom, with the score of 2; (SM) Sometimes, with the score of 3; (F) Frequently, with the score of 4; (A) Always, with the score of 5. The instrument was reliable (Cronbach's alpha = 0,97) and valid (score of Corrected Item-Total Correlation is above of r-table)

Research Procedure

Before the research is conducted, the research subjects are categorized into experimented group and controlled group. Then, the researcher coordinated with the lecturer of the subject matter for developing learning instruments, then continued to the stage of creating research instruments for the science tests as accordance with the learning materials using problem solving method. After all instruments are validated, then the identification of cognitive flexibility for all subjects of the research takes place. On the second stage, which is the treatment, the experimented group is given the treatment of problem-solving method whereas the controlled group is taught using discussion method. The next step is the distribution and filling in of the metacognitive questionnaires, and last but not least is the data analysis which is conducted to draw a conclusion based on the findings. The procedure of the research as planned by the researcher is drawn on a graph below on Figure 1;

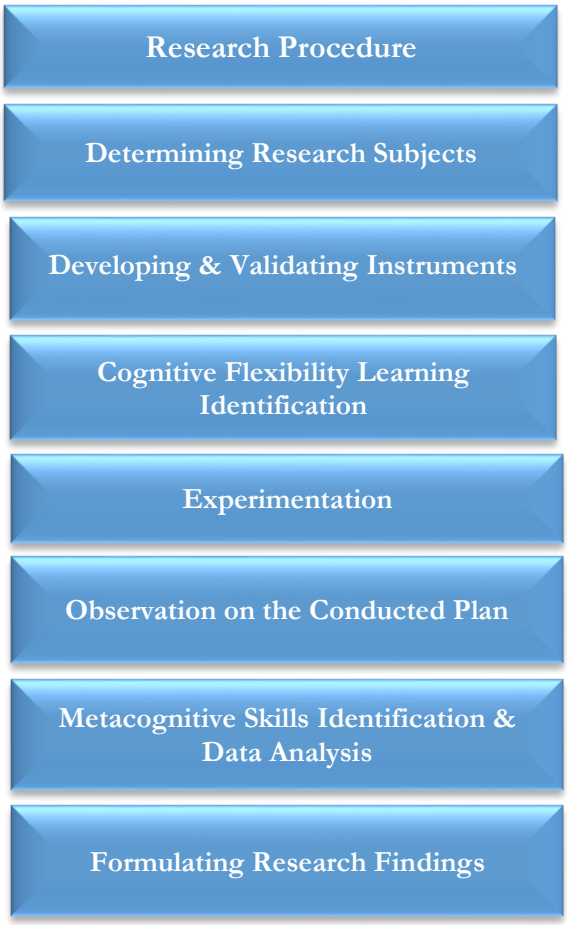

Figure 1.
Research Procedure

The steps of the treatment in research can be described as follows;

In the experimental class the lecturer uses problem solving method. He explains problem solving learning method that will be used, determines contents/subject matters and provides explanations while posing questions as a stimulus and initial information for students. The lecturer gives a task sheet containing problems that will be solved using scientific steps based on problem solving methods that are already in the task sheet. Next step, students individually

or in groups map, determine information about the contents, determine boundaries of the problem, and develop plans to solve problems, identify them, establish solutions and answer problems based on literature. Lecturers facilitate students to solve problems by giving each of them the opportunity to give statements and opinions while assessing the conclusions of each student. Students then recheck the solutions that have been determined to solve the problem written on the assignment sheet so that they find a conclusion.

In the control class the lecturer uses the discussion method. The lecturer determines the contents to be discussed, then determines the student who will discuss the contents as a speaker, and some students become the audience. Discussions will occur between students in the learning process to explore the contents by discussing their opinions to understand, then summarizing the results of the discussion which will be the core results of the debate in the discussion. And at the end of the discussion the lecturer gives a conclusion about the material discussed based on literature.

The next, steps of problem-solving method discussion method which is used in this research can be seen on the following Table 3:

Table 3.
Steps of Problem-solving Method and Discussion Method

No	Problem-solving Method		Discussion Method	
	Stages	Description	Stages	Description
1	Identifying Problems	Students are given problems to identify and instructed to comprehend and discover the most appropriate solution to solve it.	Introduction	Students acquire information from the teacher regarding topics which would stimulate their curiosity and interest to then focus in the learning and teaching activities.
2	Planning Solutions	Students explore important elements, decipher problems, and try to identify the correct problem-solving strategy. Students attempted to decide which is the answer to the problem.	Exploration	Students are involved immediately in learning and teaching activities to ensure their understanding of the materials. Students explore topics and discuss their opinions
3	Implementing	Students check each step in their solutions, and if it cannot solve the problem, then they must find a more appropriate solution. The problem-solving solution may be in the form of quantitative or qualitative solutions. Quantitative solution takes the form of selecting the correct formula to be able to answer the questions. On the other hand, qualitative solution can be done by concluding logics until the problems can be correlated to the existing logics.	Closing	Students conclude the result of the discussion as the solution to the problems.
4	Review	Students evaluate their results reasonable or not) and draw a conclusion from the findings obtained and give alternative solutions in solving the problems.		

Data Analysis

This research used quasi-experimental with post only design. The data taken was then analyzed using Independent Sample t-Test in order to determine the significance levels of the students' metacognitive skills between those with low and high cognitive flexibility levels. Prior to the implementation of t-Test, Kolmogorov-Smirnov test as the stage of homogeneity test and Levene's Test as the stage of data normality test were compulsory to pass through.

Results

Determination of Students' Have High and Low Cognitive Flexibility

In order to identify the cognitive flexibility levels of 144 students, CFI (Cognitive Flexibility Inventory) questionnaires are distributed. The identification results on their cognitive flexibility levels can be seen in the following Table 4.

Table 4.
The Identification of High or Low Cognitive Flexibility

Cognitive Flexibility	Control Class	Experimental Class
High Cognitive Flexibility	46	49
Low Cognitive Flexibility	26	23
Amount	72	72

The participants were divided into two groups as high and low in terms of cognitive flexibility levels in the experimental and control groups. As seen in Table 4, the numbers of participants are similar in the experimental and control groups according to their cognitive flexibility levels. This situation can be clearly seen in Figure 2. Thus, the groups are similar for differentiation in metacognitive skills as a result of applying different teaching methods according to cognitive flexibility level.

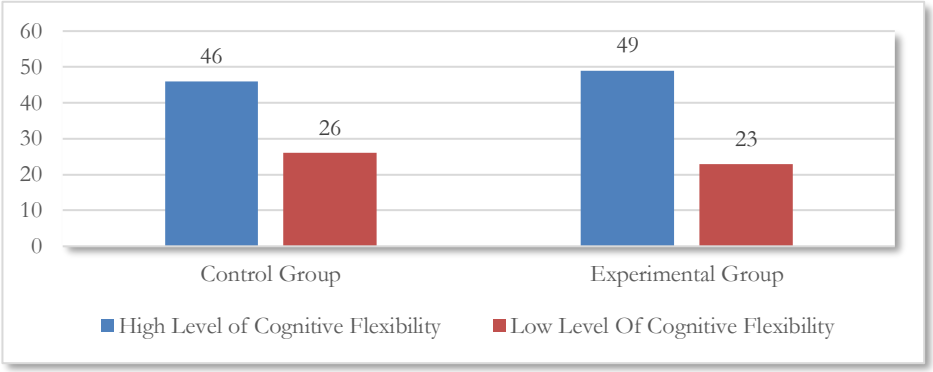

Figure 2.
The Result of The Identification of High or Low Cognitive Flexibility

Comparation of Experimental and Control Group According to Metacognitive Skills

The recapitulation of data collected on students' metacognitive skills when taught using discussion and problem-solving method is presented within the following Table 5.

Table 5.
Scores on Metacognitive Skill with Cognitive Flexibility on Controlled and Experimented Groups

Method	Cognitive Flexibility	Metacognitive Skills	
		Average	Std. Dev
Discussion	High	64.326	3.320
	Low	62.692	2.963
Problem-solving	High	92.891	2.111
	Low	90.846	2.073

Based on Table 5, it can be inferred that the controlled group which was taught using discussion method and also has high level of flexibility, scored the average of $\bar{X}$= 64.326 with the standard deviation of 3.320. On the other hand, those of low level of flexibility scored an average of $\bar{X}$= 62.692 with the standard deviation of 2.963. As for the experimented class which was taught using problem solving method, it is reported that those of high level of cognitive flexibility scored an average of $\bar{X}$= 92.891 with the standard deviation of 2.111. On the other hand, those of low level of cognitive flexibility, gained an average score of $\bar{X}$= 90.846 with the standard deviation of 2.073.

Hence, this proved that the implementation of problem-solving method on the experimented group gave a significant impact to develop students' metacognitive skills. In addition, it can be inferred that the high level of cognitive flexibility on students' metacognitive skill has a significant difference to those with low cognitive flexibility. For group discussion method, however, there was no significant impact on students' metacognitive development, and the result of students' cognitive flexibility tend to be lower as displayed in the table above.

A clearer explanation of the metacognitive results based on discussion learning method with high level of cognitive flexibility and low level as shown on Figure 3.

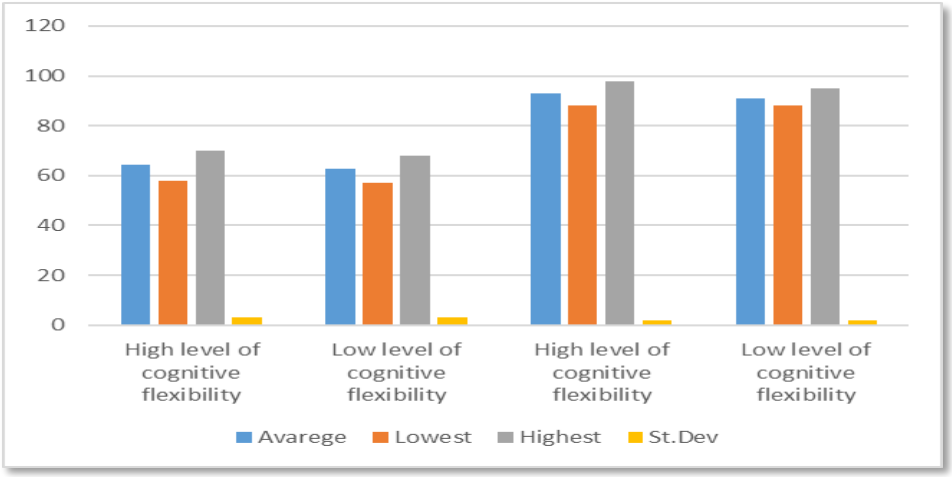

Figure 3.
The Result of The Metacognitive Levels of Cognitive Flexibility

Test of Normality

The normality of data testing is done using Kolmogorov-Smirnov, with the criteria that if the probability value > level of significance (alpha = 5%) then the data is declared normal. The results of normality data test of metacognitive skills learning outcomes in groups of students who are given discussion learning methods with high cognitive flexibility and low cognitive flexibility can be seen in table 6 below:

Table 6.
Data Normality Test Results Using the Kolmogorov-Smirnov Test

	Discussion Method		Problem-solving Method	
	High Cognitive Flexibility	Low Cognitive Flexibility	High Cognitive Flexibility	Low Cognitive Flexibility
N	46	26	49	23
Test Statistic	0.138	0.138	0.129	0.198
Asymp. Sig. (2-tailed)	0.063	0.200	0.065	0.051

Based on the table above it can be seen that the data normality test of high cognitive flexibility scores according to Kolmogorov-Smirnov statistics is 0.129 and p>0.05. The data normality test of metacognitive skills scores of low cognitive flexibility according to Kolmogorov-Smirnov statistics is 0.198 and p>0.05. And other group (control) learning outcomes of metacognitive skills with high cognitive flexibility results in Kolmogorov-Smirnov statistics is 0.138 and p>0.05. While testing the normality of metacognitive skills scores with low cognitive flexibility results in Kolmogorov-Smirnov statistics is 0.138 and p>0.05. It can be seen that the normality of metacognitive outcome data testing in the experimental and control groups of students with high cognitive flexibility and low cognitive flexibility was stated to be normally distributed.

Homogenity Variance

Next, to identify how significant the metacognitive skills of students have changed after being treated with the methods, an analysis of the low and high levels of students' cognitive flexibility on problem solving and group discussion methods are carried out by the use of Independent Sample t-Test. The result of the analysis is displayed with the help of SPSS as the following Table 7.

Table 7.
Homogeneity Variance and Indepented Sample t-Test T-Test Results Regarding Differentiation of Metacognitive Skills According to Cognitive Flexibility Level (High-Low)

Method	Homogenity (*Levene's Test*)		Independent Sample t-Test		
	F	Sig.	t	df	Sig. (2-tailed)
Discussion (Cognitive Flexibility High-Low)	1.431	0.236	2.083	70	0.041
Problem-solving (Cognitive Flexibility High-Low)	0.576	0.450	3.975	70	0.000

As a result of the research, it was found that there was a significant difference in the metacognitive skills of students with high cognitive flexibility and low cognitive flexibility. This differentiation is in favor of students with high cognitive level. As can be seen in Table 7, it can be said that the variances of each group are homogeneous with Levene's test. According to the Independent Samples t-Test results, it was determined that there was a differentiation from metacognitive skill scores for groups with high and low cognitive flexibility in both teaching methods ($p<.05$).

High cognitive flexibility is the cognitive function that allows the individual to manage unusual familiar situations. This type of individuals can easily manage, design, and evaluate the problems given without feeling pressured. Hence, the proven high score of students' metacognitive skills displayed in the above research data is aligned with the previous theories and existing research (Spiro & Jehng, 1990; Cartwright, 2008). The higher the students' cognitive flexibility, the more opportunities of cognitive shifts will take place to adapt oneself with the condition. Likewise, the lower the students' cognitive flexibility level, the more complications will be faced by the students.

Developing Learner's Metacognitive Skills Using Discussion and Problem-Solving Method

The metacognitive development between groups taught using problem solving learning methods are recapitulated to get the general idea of the research subjects' initial conditions. The recapitulation of learning outcomes on students' metacognitive skills of Elementary School Teacher degree is presented on Table 8 as the following:

Table 8.

Developing Learners' Metacognitive Skills Using Discussion and Problem-solving Methods

Learning Methods	Metacognitive Skills	
	Mean	Std. Dev
Discussion Method	63.736	3.272
Problem Solving Method	92.153	2.305

Based on the Table 8 above, it can be inferred that experimented group which learned through discussion method gained an average score of $\bar{X}$= 63.736 for their metacognitive skills' developments and with the standard deviation of 3.272. On the other hand, the experimented group which learned using problem-solving method reached the average of $\bar{X}$= 92.153 with the standard deviation of 2.305. A clearer figure of the metacognitive skills' developments results using discussion and problem-solving methods on students is presented in the following Figure 4:

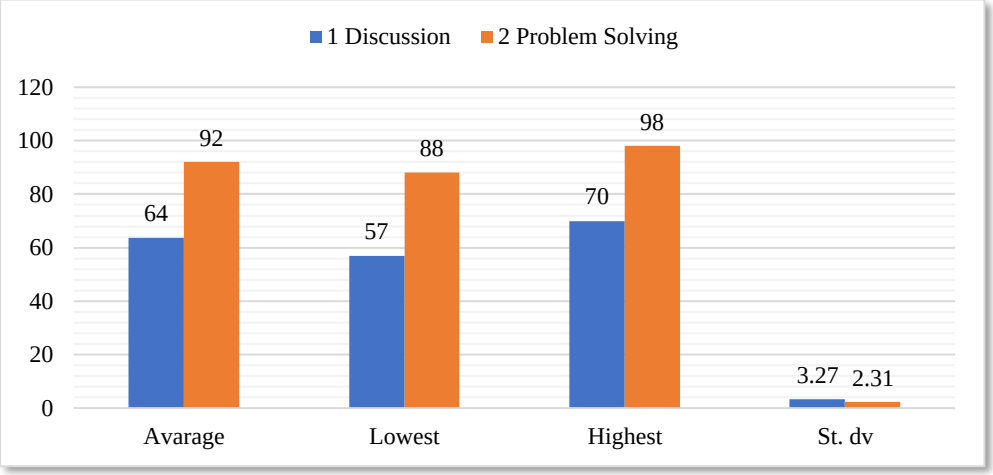

Figure 4.

Results of the Metacognitive Skills Score of Students Taught Using Methods

Normality Data

Data normality testing is done using Kolmogorov-Smirnov, with the criteria that if the probability value> level of significance (alpha = 5%) then the data is declared normal. The results of metacognitive data normality of group of students who were given discussion learning methods and problem-solving methods can be seen in the following Table 9.

Table 9.
Data Normality Test Results Using the Kolmogorov-Smirnov Test

	Method	
	Discussion	**Problem Solving**
N	72	72
Test Statistic	0.105	0.129
Asymp. Sig. (2-tailed)	0.079	0.054

Based on the above table, it can be seen that data normality test of learning outcomes of metacognitive skills in groups of students who are given discussion learning methods produces Kolmogorov-Smirnov statistics of 0.05 with a probability of 0.079. While testing the normality of students' metacognitive skills learning outcomes in groups of students who were given problem solving learning methods resulted in Kolmogorov-Smirnov statistics of 0.129 with a probability of 0.054. It can be seen that test of the normality of data on learning outcomes of metacognitive skills in groups of students who are given discussion learning method and problem-solving method is declared normal.

Homogenity of Variance

To identify how significant the students' metacognitive skills after given the problem solving and discussion methods, an analysis using Independent Sample t-Test is conducted, the result of the analysis using SPSS is displayed in Table 10 as the following:

Table 10.
Test of Homogeneity of Variances and Indepented Sample t-Test Results Regarding Differentiation of Metacognitive Skills According to Teaching Methods (Discussion-Problem-solving)

Homogenity (L*evene's Test)*		**Independent Sample t-Test**		
F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
1.493	0.070	60.246	142	0.000

The normal distribution status of the data obtained from the participants was shown in Table 9. Now, Levene's test results on whether these given variances are equal are shown in Table 10. Accordingly, it can be said that the data on the two groups taught according to the method of discussion and problem solving have an equal variance ($p>.05$).

After the assumption of equality of variances is completed, the differentiation of students' metacognitive skills according to the method of application teaching was examined with Indepented Sample t-Test. Accordingly, a significant difference was determined between the metacognitive skill scores of the two groups in which discussion and problem solving method was applied (<0.05, H_0 is rejected). It is seen that this differentiation is in favor of problem-solving method.

The results displayed on the Table 10 above proves that the appearance of obstacles in problem solving method in learning and teaching enables students to feel challenged and condition their abilities to be able to overcome those obstacles. This ability helps students to maximize their problem-solving skills and critical thinking. Therefore, problem solving method has high potentials in developing students' metacognitive potency. This can be investigated through analyzing the steps of problem solving method, as it is directed towards finding a solution to solve a problem while also offering a thinking practice which can open opportunity for students to measure their abilities and select the most appropriate strategy to solve the problem. In other words, after being treated with problem solving and group discussion methods, students' metacognitive skills in the experimented and controlled groups are significantly different.

Discussion and Conclusion

Based on the research finding, it is confirmed that there is a significant difference found in higher metacognitive skill development of teacher candidates with high level of cognitive flexibility than those of low level. Learners with high flexibility level tend to be able to adjust themselves in various conditions within learning and teaching process, which enable their thinking process to work smoothly, without obstacles nor pressures. High level of cognitive flexibility on students can also enable them to expand one's metacognitive skills as the ability allow students to easily adapt with different materials and conditions. As a result, they will be at ease in managing themselves and processing information which they gained throughout the learning process. Cognitive flexibility refers to the transfer of knowledge which can be defined as an ability to construct one's knowledge through many ways in adapting with the changing situations and

demands. Learners with high level of cognitive flexibility can easily understand any type of materials given as their cognitive structure tends to change easily (Spiro & Jehng, 1990).

Hence, this finding strengthens previous background literature which discusses how cognitive flexibility can help develop students' metacognitive skills. Several of those studies include one conducted by Eslinger & Grattan (1993), discovered that cognitive flexibility in general refers to the ability to change cognitive instruments, the ability to acknowledge, to comprehend a situation, processing, and responding to situations through many ways. Elen, et al. (2011) explained that learners with low cognitive flexibility will have a slow change of mind and undergo pressures when facing a different condition which is no longer structured. Gnaedinger, et al. (2016) stated that high level of cognitive flexibility is perpendicular with one's ability to think and comprehend contents while also affecting their ability in implementing strategies effectively within learning and teaching process. Cole, Duncan & Blaye (2014) also added that the growth of reading requires high level of cognitive flexibility in order to process information. Within a study, cognitive flexibility is defined as people who had just realized ways and alternatives of choices, acting flexible in adjusting themselves into the new situation, believing they are able to survive in that situation (Onen & Canan, 2014).

The relationship of cognitive flexibility and metacognitive is also expressed by Bilgin (2009) that it can trigger learners to think positively throughout the lessons, causing their behaviours and attitudes to become like so as well. Galyam & Grage (2005) stated that the ability to adapt with changes depend on one's cognitive ability to make a decision based on reasoning, analysis, and information process. The ability to adapt with a complex material and in an uncommon situation becomes a response in the form of idea, notions, and cognitive strategies. Thus, based on the findings on this research and empirical data of previous studies, it is proven that the level of flexibility affects a students' metacognitive skill. As explained by Taylor (2009), the ability to think flexible in solving problems will produce success for the students. Hence, it is critical for students to have a high level of flexibility.

In addition, the effect of problem-solving method on one's metacognitive skill based on the data being analyzed proved that generally, students' metacognitive skills when taught using problem solving method can develop better than those who are taught by discussion method. This means that there is a significant difference in the development of students' metacognitive skill when taught by the certain learning methods despite the materials, facilities, and essay questions given remaining the same. The differences on students' metacognitive skills development taught by problem solving method and discussion method proved that learning methods do affect learners' thinking patterns. Due to this very reason, it is important for teachers to select the most appropriate learning method before the classroom activities are conducted. The learning method is then matched with the appropriate materials and learners' characteristics in order to reach the maximum learning outcomes. Because there are also researches that criticize the use of the problem-based learning (Ramadhani, Huda & Umam, 2019). The selection of problem solving method to stimulate students' thinking process in learning activities is important to develop their ways of thinking and solving a problem, using the solution as their foundation of learning process (Heong, 2011). When learners also take role in a learning process, it will impact significantly on their thinking process which can help develop their metacognitive skills.

This research findings are also aligned with Jagals & Van der Walt (2016)'s discovery on students' metacognitive reflection which construct students, their task and strategy awareness, particularly through the regulatory process in which metacognition is embedded through problem-based learning. Learners will then be able to be actively involved in learning and teaching activities, feeling responsible to solve problems in the classes, which can help develop an internal motivation within the students. Taccasu (2008) also agreed that problem solving method greatly helps students in improving their metacognitive skill since the steps of the learning method guides learners on how they should behave towards a problem, how they should comprehend it, design a solution, implement the solution and doing corrections on answers they have decided on. Wesson (2013) also added that problem solving method is proven to be an effort to overcome difficulties, a way to encounter challenges, a strategy to find ways in approaching the goal, where it is not easy to be reached. Haryani et al. (2018) discovered that the application of problem-based learning greatly improve students' metacognitive skills, and therefore influenced the students' reasoning skills in solving problems significantly. Thus, as summed up by the studies above, during learning process, problem solving method is highly suggested to be implemented by teachers in triggering students to continue thinking on how they can solve problems given in the form of data which needs to be solved. Learners will learn to transform these data as information they require in search for new resources in a learning process (Song & Park, 2017). Throughout this process, the learners' metacognitive skills are unconsciously being developed as it includes the steps of planning, contemplating, monitoring, and drawing conclusion, which makes learning process easier. Therefore, instead of using conventional methods in classrooms such as memorizing, classroom activities such as thinking things out using problem solving

method becomes much more challenging and interesting for students as they must be able to investigate the solution to the problem found at the same time, this develops the students' metacognitive skills (Avargil et al. 2018).

To conclude, there are significant differences on the metacognitive skills of students with high levels of cognitive flexibility when compared to those of low level cognitive flexibility. It can be confirmed that those with high levels of cognitive flexibility can develop their metacognitive skills faster, producing a much better learning outcomes than those of low level cognitive flexibility. They are also able to adjust with their surroundings as according to each condition. Students with low levels of cognitive flexibility tends to think slower and are unable to handle the pressure of being put in a different environment. Last but not least, there are also significant differences found in students' metacognitive skills in terms of the different learning methods used to teach them: discussion and problem-solving methods. Students who are taught using problem solving method has greatly developed their metacognitive skills than those who are taught using discussion method. Problem solving methods push students to become more careful and tend to think critically when investigating solutions to a challenge they find. Teachers in the future must consider the implementation of problem-solving methods in their classroom to develop students' metacognitive. The higher their levels of cognitive flexibility, the faster they can develop their metacognitive skills which would be of a convenient use in the future.

Recommendations

Overall, this research can be recommended for those who wish to explore similar studies and find out ways in which learning activities can become more successful. In near future, the researcher recommend that learning and teaching activities at university level, especially courses which aimed to develop students' metacognitive skills, should implement the use of problem solving method and pay attention on the cognitive flexibility of the students to be adjusted with that of the materials of the course. The researcher also suggests for future studies relating to this research to develop a more detailed and enhanced study, perhaps in qualitative design. This research can also be further improved by designing a research and development-based study by integrating problem-solving method or cognitive flexibility with other variables for the better advancement of educational research and education system development.

Acknowledgements

This research was supported by the Ministry of Religious Affairs (MORA) 2016 Republic of Indonesia and Universitas Negeri Malang. Highest gratitude towards the teachers, students, and everyone who have helped the researcher in conducting this study.

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References

Ali, R. (2010). Effect of using problem solving method in teaching mathematics on the achievement of mathematics students. *Journals of Asian Social Science*, *6*(2), 67-72.doi:10.5539/ass.v6n2p67

Akbenm N. (2018). Effects of the problem-posing approach on students' problem solving skills and metacognitive awareness in science education. *Research in Science Education* (2018): 1-23.doi:10.1007/s11165-018-9726-7

Anderson, L. W., & Krathwohl (eds.). (2010). *A taxonomy for learning, teaching and assessing: A revision of bloom's taxonomy of educational objectives: Abridged edition.* Addison Wesley Longman, Inc. Pearson.

Avargil, S., Lavi, R., & Dori, Y. J. (2018). Students' metacognition and metacognitive strategies in science education. *Cognition, Metacognition, and Culture in STEM Education* (pp 33-64). Springer, Cham.

Bilgin, M. (2009). Developing a cognitive flexibility scale: Validity and reliability studies. *Social Behavior and Personality: An International Journal*, *37*(3), 343-354. https://doi.org/10.2224/sbp.2009.37.3.343

Cartwright, K.B. (2008). *Introduction to Literacy Processes: Cognitive Flexibility in Learning and Teaching.* New York, NY: Guilford Press(pp. 3-15)

Cartwright, K.B., Marshall, T.R., Dandy, K. & Isaac, M.C. (2010). The development of graphophonological-semantic cognitive flexibility and its contribution to reading comprehension in beginning readers. *Journal of Cognition And Development*, *11*(1), 61-85.doi:10.1080/15248370903453584

Cole, P., Duncan, L., & Blaye, A. (2014). Cognitive flexibility predicts early reading skills. *Frontiers in Psychology*, *5*(18), 565. https://doi.org/10.3389/fpsyg.2014.0065

Corebima. A.D. (2009). *Pengalaman Berupaya Menjadi Guru Profesional, Pidato Pegukuhan Guru Besar Dalam Bidang Genetika*. Malang : FMIPA. Universitas Negeri Malang.

Coskun, A. (2010). The effect of metacognitive strategy training on the listening performance beginner student. *Research on Youth and Language*, *4*(1), 35-50.

Dang, N.V., Chiang, J.C., Brown, H.M., & McDonald, K.K. (2018). Curricular activities that promote metacognitive skills impact lower-performing students in and introductory biology course. *Journal of Microbiology & Biology Education,19*(1).

Dawson, T. (2016). Metacognition and Learning in Adulthood, South Park Terrace: Northampton. Retrieved from http://Dts.Lctica.Org/PDF/Metacognition.Pdf)

Degeng. I.N.S. (2013). *Ilmu Pembelajaran: Klasifikasi Variabel Untuk Pengembangan Teori dan Penelitian*. Bandung: Kalam Hidup.

Delors, J. (2013). The treasure within: Learning to know, learning to do, learning to live together and learning to be: What is the value of that treasure 15 years after its publication. *International Review of Education*, *59*(3), 319-330. https://doi.org/10.1007/s11159-013-9350-8

Dennis, J.P. & Vander, W.J.S. (2010). The cognitive flexibility inventory: Instrument development and estimates of reliability and validity. Cognitivetherapy and research. *Springer Science Business Media*, *34*, 241-253. doi:10.1007/s10608-009-9276-4

Eggen P., & Kauchak, D. (2012). *Strategies and Models For Teacher Teaching Contens and Thinking Skills (6th Edition)*. Boston: Pearson Publishing

Elen, J., Stahl, L., & Clarebout, G. B. R. (2011). *Links Between Beliefs And Cognitive Flexibility: Lessons Learned*. Netherlands: Springer, 42-43.

Fazey, I., Fazey J. A., Fischer, J., Sherren K., Warren, J., Noss R. F., and Dovers, S. R. (2007). Adaptive capacity and learning to learn as leverage for social-ecological resilience. *Frontiers in Ecology and the Environment*, *5*(7), 375–380. doi:10.1890/1540-9295(2007)5[375:ACALTL]2.0.CO;2

Flavell, J. (1976). *Metacognitive Aspects of Problem Solving. The Nature of Intelligence.* Hillsdale, NJ: Earlbaum, 231-235.

Galyam, N. & Le Grange, L. (2005). Improving thinking skills in science of learners with (dis)abilities. *South African Journal of Education*, *25*(4), 239-246.

Garrett, A.J. & Mazzocco, M. (2006). Development of the metacognitive skills of prediction and evaluation in children with or without math disability. *Learning Disabilities Research & Practice*, *21*(2), 77-87. doi:10.111/j.1540-5826.2006.00208.x

Gezer-Templeton, P. G., Mayhew, E. J., Korte, D. S., & Schmidt, S. J. (2017). Use of exam wrappers to enhance students' metacognitive skills in a large introductory food science and human nutrition course. *Journal of Food Science Education, 16*(1), 28-36.

Gnaedinger ,E. K., Hund, Alycia. M., & Hesson, M. S. H. (2016). Reading specific flexibility moderates the relation between reading strategy use and reading comprehension during the elementary years. *Mind, Brain And Education*, *10*(4), 233-246.doi:10.111/mbe.12125

Greenstein, L. (2012). *Assessing 21st Century Skills: AGuide to Evaluating Mastery and Authentic Learning.* United Kingdom: SAGE Publicaions Ltd.

Haryani, S., Wijayati, N., & Kurniawan, C. (2018). Improvement of metacognitive skills and students' reasoning ability through problem-based learning. *Journal of Physics: Conference Series*,*983*(1), 012174.

Heong, P., M., Yunos, J.B., & Hassan, R.B. (2011). Thelevel of marzano higher ordet thinking skills among technical education student. *International Journal of Social Science and Humanity*,*1*(2), 121-125.

Huang, F. H.; Ricci, F. A., Mnatsakanian, M. (2016). Mathematical teaching strategies: Pathways to critical thinking and metacognition. *International Journal of Research in Education and Science*, *2*(1), 190-200.

Jagals, D., & Van der Walt, M. (2016). Enabling metacognitive skills for mathematics problem solving: A collective case study of metacognitive reflection and awareness. *African Journal of Research in Mathematics, Science and Technology Education, 20*(2), 154-164.

Jonassen, D. H., (2011). *Learning to Solve Problems: A Handbook For Designing Problem-Solving Learning Environments*. New York: Madison Avenue.

Kim, M. C. & Hanafin, M. J. (2011). Scaffolding problem solving in technology–enhanced learning environment (TELES): Bridging research a theory with practice. *Computer & Education: An International Journal*, *56*(2), 403-417.

Matlin, M.W. (2009). *Cognitive Psychology (Seventh Edition)- International Student Version.* United Kingdom: Jhon Wiley and Sons, Inc.

Onen, A.S. & Canan K. (2014). The effect of cognitive flexibility on higher school students'study strategies. *Procedia-Social and Behavioral Sciences*, *191*, 2346 – 2350.doi:10.1016.j.sbspro.2015.04.680

Paidi. (2008). Pengembangan Perangkat Pembelajaran Biologi Yang Mengimplementasikan PBL Dan Strategi Metakognitif, Serta Efektifitasnya Terhadap Kemampuan Metakognitif, Pemecahan Masalah, Dan Penguasaan Konsep Biologi Siswa SMA Di Sleman Yogyakarta.*PPS Universitas Negeri Malang*. Malang

Polya, G. (2004). *How to Solve It (Jhon Conway, Ed)*. United State Of America: Princenton University Press.

Ramadhani, R., Huda, S., & Umam, R (2019). Problem-Based Learning, Its Usability and Critical View as Educational Learning Tools. *Journal of Gifted Education and Creativity, 6*(3), 219-231.

Reigeluth, C.M. & Carr-Cheliman, A.A. (2009). *Instructional-Design Theories and Models : Building a Common Knowledge Base: Volume III*. New York and London : Taylor and FrancisPublishers.

Reisenberg, D. (2007). *Cognition: Exploring in the Science of The Mind.* United State of America: W.W. Norton & Company.

Rosa, F. (2015). Analisis Kemampuan Siswa Kelas X pada Ranah Kognitif, Afektif, dan Psikomotorik. *Omega: Jurnal Fisika dan Pendidikan Fisika, 1*(2), 24-28

Schraw, G., & Denniso R.S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, *19*(4), 460-475. doi:10.1006.ceps.1994.1033

Safari, Y., & Meskini, H. (2016). The effect of metacognitive instruction on problem solving skills in Iranian students of health sciences. *Global Journal of Health Science, 8*(1), 150

Setyosari, P. (2016). *Metode Penelitian Pendidikan & Pengembangan.* Jakarta: Prenadamedia Group.

Song, J.Y., & Park, J.E. (2017). The effects of strategy of enhanced metacognition on the improvement of creative problem solving skills. *Journal of Digital Convergence, 15*(7), 1-12

Spada, M.M., Giorgeou, G.A., & Wells, A. (2010). The relationship among metacognition, attention control, and state anxiety.*Cognitive Behavior Therapy*, *39*(1), 64-71.doi:10.1080/16506070902991791

Spellman, K.V., Schneller L.C., Mulder C.P.H., & Carlson, M.L. (2015). Effects of non- native melilotus albus on pollination and reproduction in two boreal shrubs. *Oecologia*, *179*, 495–50. doi:10.1007/s00442-015-3364-9

Spiro, R. J.& John C Jheng.J. C. (1990). *Cognitive Flexibility and Hypertext: Theory and Technology for the Nonlinear and Multidimensional Traversalof Complex Subject Matter*. New York: Watson Research Center Rand Spiro Universiry Of Illinois At Urbano-Champaign.

Su, A., Ricci, F. A., & Mnatsakanian, M. (2015). Critical thinking as a mathematical problem-solving strategy: Classroom scenario. *Dimensions in Mathematics, 35*(2), 19

Syah, M. (2013). *Psikologi Pendidikan Dengan Suatu Pendekatan Baru (Edisi Revisi)*. Bandung: PT. Remaja Rosdakarya.

Taccasu, P. (2008). Metacognition.Retrieved from http://www.Hku. Cepc/taccasu/ref/metacognition.html

Taylor, S. (2009). *Health Psychology (Seventh Edition)*. New York: Mc Graw-Hill Companies, Inc.

Tortop, H.S. (2015). A comparison of gifted and non-gifted students' self-regulation skills for science learning. *Journal for the Education of Gifted Young Scientists*, *3*(1), 42–57.

Tuckman, B.W. (1999). *Conducting Educational Research*. United States of America: Earl McPeek

Wesson, R.H. 2013. Development of The Problem Solving Teaching. Retrieved from http://www.deakin.edu.au/_data/asset/pdf_file0012/51240/problem-solving.pdf