The development of metacognitive awareness related to the implementation of metacognitive-based learning

H Novia¹*, I Kaniawati², A Rusli³ and D Rusdiana²

¹ Graduate School, Universitas Pendidikan Indonesia
² Physics Education Department, FPMIPA, Universitas Pendidikan Indonesia
³ Catholic Parahyangan University, Bandung, Indonesia

*Corresponding author: heranovia@yahoo.com

Abstract. Numerous studies suggested that metacognition is an essential thing in students' learning because it will affect how student apply what they had learned to study new knowledge. Therefore, this study aims to explore the development of metacognitive awareness through metacognitive-based learning that consist of 5 stages: identification, define the problem, examine the solution, act the strategy, and the last look back and evaluate, all of these stages were integrated to metacognition. Metacognitive Awareness Inventory questionnaire was employed for data collection to 17 pre-service physics teachers on solid-state physics lecture, in Bandung. This questionnaire consists of 56 items that focus on metacognitive knowledge and metacognitive regulation. The analysis of questionnaire data showed that the development both of metacognitive knowledge and metacognitive control quite good, it means that learning process promoted the awareness in learning and thinking process.

1. Introduction

Learning is a process in which, the teacher is not as the center of learning but students must be actively involved and recognize their responsibility for education [1]. Learners use existing knowledge to make sense of new information or knowledge. The universal goal of science learning is to improve the understanding of science concept. Metacognition is essential for learning science and is one of the factors that contribute to academic performance and success. Students with poor metacognition need some training of metacognition to improve academic performance and metacognition [2].

The teacher is a crucial factor to improve the metacognitive awareness. There is a need for students to develop metacognitive demands, so they aware of altering and enhancing their learning process. If the teacher knows metacognitive awareness of students, they can find how well students learn science so that the teachers can encourage students' ability in learning. Metacognition affects not only the acquisition, understanding, retention, and application of what is learned; but it also affects the efficiency of knowledge, critical thinking and problem-solving. Awareness of metacognition can also lead students to become more thoughtful, knowledgeable, and the most important ultimately help them to more responsible for their learning.

Research activity in metacognition began with John Flavell refers to metacognition as one's knowledge that concern to cognitive process and product, active monitoring and regulating one's cognitive process. Researcher in psychological education have investigated that some variables contribute to academic performance, and one of them is metacognition. Several terms commonly associated with research on metacognition: metacognitive beliefs, metacognitive experiences, feeling
of knowing, metacognitive skills, self-regulation, metamemory, metacognitive knowledge, judgment of learning, metacognitive awareness, etc. [3]. Others said metacognition refers to the ones' understanding of his cognitive processes and the ability to control and monitor cognition processes as feedback of learning activity [4].

Metacognition is one type of high order thinking. To distinguish metacognitive thinking of other kinds of thinking, it is necessary to consider the source of thought. Metacognitive thinking is not something that suddenly comes from outside, but is a one's mental representation, that includes what one knows about internal representation, how the description works, and how one feels the representation.

There are two essential components of metacognition; metacognitive knowledge and metacognitive regulation [5]. Metacognitive knowledge refers to the understanding of cognition such as knowledge of skills and strategies and knowhow and when use skills and approach to do the best in learning. Metacognitive regulation applies to activities to control one's thinking and learning [2]. Metacognitive knowledge can be classified into three aspects: declarative knowledge, procedural knowledge, and subject knowledge and metacognitive regulation consist of five elements: planning, management information, monitoring, debugging, and evaluation [6].

Learning physics is a difficult task for many students, and students' achievement is lower than others. Physics was distinguished from other sciences because of its extremely high levels of abstraction and idealization [7]. Therefore, an improvement in metacognitive awareness is a key to improve science learning [8]. Because of the importance of metacognition in education, this study aims to explore the metacognitive awareness development of pre-service physics teachers after receiving metacognitive-based learning.

2. Methods
The Solid State Physics studies about how large-scale properties of solid material result from their atomic-scale properties. The arrangement of atoms in Solid State relates to material properties. Solid-state physics is also the theoretical basis for material science and has a substantial contribution to the technology. The properties of material caused by the arrangement of atoms.

Metacognitive-based Solid-State Physics learning was the study of Solid-State Physics which adopts problem-solving learning stages IDEAL, which each stage was integrated with metacognition awareness aspects. The steps consist of (I) Identify the problem, (D) Define the problem, (E) Explore the solution, (A) Act the settlement, the last (L) Look-back and evaluate [9]. In this study, metacognition was comprised of two major components: Metacognitive knowledge refers to knowledge of cognition such as knowledge of skills and strategies that work best for the learner, and how and when to use such skills and approach. Metacognitive regulation refers to activities that control one's thinking and learning such as planning, management information, monitoring, debugging, and evaluating [10].

Participants for this study were 17 Physics-service teachers enrolled in Physics Solid State Physics course. The instrument namely metacognitive awareness inventory (IKM) that was adapted from the Metacognitive Awareness Inventory of Schraw and Moshman [6]. The tool included brief cover instruction, 56 items, on a 4-point scale ranging from (4) to (1) and at the end were classified to the right and not good categories. This inventory includes two components of metacognition, metacognitive knowledge, and metacognitive regulation. Individuals completed this inventory before and after learning and were seen whether there was a development of metacognitive awareness after six weeks metacognitive-based learning implementation.

The instruments that used in this study were metacognitive knowledge journal, discussion worksheet that presented a problem in which students had to complete individuals, followed by learning media as source information, and then group discussion. Further, the visual media was presented during the learning.
3. Result and Discussion

Table 1 shows that the average of metacognitive awareness inventory before metacognitive-based learning obtain 2.81 and after implementation is 2.99. The results of the Pre-test and post-test show that there is an increase in metacognitive awareness after participants experience metacognitive-based solid-state physics learning. Overall, the average of metacognitive awareness for each aspects increase, although the growth is in the range (0.5-8.5)%. It means that metacognitive-based learning successfully increases metacognitive awareness. It shows that the standard deviation for post-test for each aspect is smaller than pre-test standard deviation, which means that metacognitive-based knowledge has significant equality for each element. According to participants, one of the factors that cause the improvement is not too high because of the difficulty of the material, that the concept is abstract so it is not easy to understand. These characteristics of learning material lead to an increase in metacognitive awareness not so high. Management information and evaluation are two of all aspects that change better. It was mean that metacognitive-based learning trained the participants better to manage data during education and evaluate the learning process.

| Component          | Aspect                   | Pre-test Mean | Post-test Mean | Pre-test SD | Post-test SD |
|--------------------|--------------------------|---------------|----------------|-------------|--------------|
| Metacognitive      | Declarative (MP-1)       | 2.99          | 3.19           | 0.641       | 0.588        |
| Knowledge          | Procedural (MP-2)        | 2.98          | 3.01           | 0.685       | 0.657        |
|                    | Conditional (MP-3)       | 2.83          | 3.01           | 0.728       | 0.645        |
| Metacognitive      | Planning (MR-1)          | 2.69          | 2.85           | 0.897       | 0.711        |
| Regulation         | Management Information (MR-2) | 2.63      | 2.95           | 0.818       | 0.796        |
|                    | Monitoring (MR-3)        | 2.71          | 2.76           | 0.817       | 0.685        |
|                    | Debugging (MR-4)         | 3.02          | 3.25           | 0.781       | 0.770        |
|                    | Evaluation (MR-5)        | 2.61          | 2.90           | 0.761       | 0.754        |

**Figure 1.** Graph of mean metacognitive awareness inventory relate to metacognitive-based learning.

Figure 1 shows that the average value of almost all of the aspects is still below the scale 3 before learning, while after experiencing metacognitive-based education some aspects have reached scale 3, such as declarative knowledge, procedural knowledge, and subject knowledge. In other words, all elements of metacognition knowledge are already on a scale above 3 and are categorized well.

In Table 2, there is a grouping of metacognitive awareness inventories that are divided into good and not good categories, before and after metacognitive-based learning.
Table 2. Classification of metacognitive awareness inventory

| Component          | Aspect                               | Good (%) | Not Good (%) |
|--------------------|--------------------------------------|----------|--------------|
|                    | Pre-test                             | Post-test| Pre-test     | Post-test     |
| Metacognitive      | Declarative (MP-1)                   | 77.65    | 87.65        | 22.35         | 12.35         |
| Knowledge          | Procedural (MP-2)                    | 72.55    | 84.31        | 27.45         | 15.69         |
|                    | Conditional (MP-3)                   | 64.71    | 80.67        | 35.29         | 19.33         |
| Metacognitive      | Planning (MR-1)                      | 58.82    | 71.57        | 41.18         | 28.43         |
| Regulation         | Management Information (MR-2)        | 57.52    | 67.47        | 42.48         | 35.53         |
|                    | Monitoring (MR-3)                    | 61.34    | 56.52        | 38.66         | 43.48         |
|                    | Debugging (MR-4)                     | 72.94    | 87.06        | 27.06         | 12.94         |
|                    | Evaluation (MR-5)                    | 57.84    | 67.65        | 42.16         | 32.35         |
| Mean               |                                      | 65.42    | 75.36        | 34.57         | 25.01         |

From the average it was obtained that there is the increasing approximately 10% for the right category which is a shift from the not good type that during the pre-test 34.57% to 25.01% has resulted in the post-test. Some aspect increase more than 10% for good categories, such as procedural knowledge increased by 11.76%, debugging obtained 14.12% and 12.75% for planning. Metacognitive Awareness needs to be trained after metacognitive-based learning experience preservice teacher had the better result [9].

Figure 2 shows the distribution of metacognitive awareness of pre-service physics teachers who have an excellent category. Both, before and after learning, all aspects have a right metacognitive awareness category, and almost all aspects percentages increase in the right type. Figure 3 states the distribution of groups that had not good awareness of metacognition, the decline in the number of the rate at the not right category that means shifted into a good group.

Figure 2. Graph of metacognitive awareness inventory in metacognitive-based learning.
The result of this implementation because of the improvement of computer-based resources and social interaction. The change to their class interaction can stimulate differences in students' approaches to learning. Group discussion is one of the ways to enhance metacognitive awareness (Figure 3). Social interaction promotes cognitive development, and that is why they recommend the use of debate for encouraging the development of metacognitive awareness. Metacognitive development is obtained by asking to reflect on and monitor their learning performance [11].

A person's knowledge is a continuous process of development that occurs in an evolutionary manner [12]. In its development, some have experienced significant changes, some of which are not. Students often enter the class carrying concepts that are not by scientists. Some teachings including discussion can be used to change students' thoughts. Teachers should give students the opportunity to be aware of inappropriate conceptions by arguing about their interpretations and expressing them in scientific explanations. There are significant improvements and changes in student achievement using learning activities to develop metacognition skills [14].

4. Conclusion
The result of this research shows that there is an increasing percentage amount for a group having an excellent category of metacognitive awareness. Also, the average inventory of metacognitive awareness after implementation is higher than before metacognitive-based learning. It can be concluded that metacognitive-based education can develop the metacognitive awareness of pre-service physics teachers.

References
[1] Kirbulut Z D, Uzuntiryaki-Kondakci E, and Beeth M E 2016 *Int J Sci Educ* **38** 1 22
[2] Coutinho S A 2007 *Educate* **7** 39
[3] Rompayon P, Tambunchong C, Wongyounoi S, and Dechsri P 2010 *Int Assoc Educ Assess* **11** 7
[4] Chantaranuwong W, Thathong K, and Yuenyong C 2012 *Procedia-Soc Behav Sci* **46** 5085
[5] Gok T 2014 *Eurasia J Math Sci Technol Educ* **10** 617
[6] Schraw G and Dennison R 1994 *Contemp Educ Psychol* **19** 460
[7] Thomas G P 2013 *Int J Sci Educ* **35** 1183
[8] Zohar A and Dori Y J 2012 Metacognition in Science Education: *Trends in current research* (Dordrecht: Springer)
[9] Bransford J and Stein B 1984 The IDEAL Problem Solver: *A Guide for Improving Thinking, Learning, and Creativity* (New York: W. H. Freeman)
[10] Delgado C 2014 *J Sci Educ Technol* **98** 305
[11] Sandi-Urena S, Cooper M M, and Stevey R H 2011 *Int J Sci Educ* **33** 323
[12] Saglam A and Deveciogle Y 2010 *Asia-Pac Forum Sci Learn Teach* **11** 1

[13] Rekabdar S, Behrouzi P, and Hakhverdian A 2015 *Int J Educ Investigations* **2** 171