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Promoting Students' Metacognition in Natural Product Chemistry Course through Mini Project Laboratory

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Abstract

This research was *ex post facto* design that aimed to examine an application of the natural product mini project laboratory in order to improve the students' metacognition. The research subjects were students of Chemistry Education, Faculty of Teacher Training and Education, Mataram University who programed Natural Product Chemistry Course. The results of the data analysis showed that the profile of students' metacognition skills increased after the application of a Mini Project Laboratory of Natural Product Chemistry. Students who have high GPA also had high metacognition skills. The highest percentage of high categories was planning metacognition indicators, whereas the lowest percentage was the conditional knowledge indicator.

Subject Areas

Education

Keywords

Metacognition, Mini Project Laboratory, Natural Product Chemistry

1. Introduction

Natural product chemistry (NPC) course is a course that studies various secondary metabolites, ranging from structure, biosynthetic pathways, reactions, structure determination, how to use it and how to isolate it. NCC learning activities are often carried out only by providing theory without doing laboratory work. In fact, the isolation process is carried out by students in laboratory activities. Laboratory activity is an important component of undergraduate science education. Nevertheless, in Indonesia, the natural product chemistry course is

not supported by laboratory activities although Indonesia has a very high diversity of plants that can be used in natural product chemistry laboratories [1].

NPC laboratory activities can be in the form of projects which are one of the laboratory activities that give students opportunity to think. Project-based laboratory activities give students opportunity to design their own activities to be carried out in the laboratory. This makes students become active in learning. This activity can facilitate students to connect different disciplines as a basis for designing small or large studies, so they can develop their creativity and experience [2].

Learning achievement at the tertiary level such as undergraduate is set to be equivalent to the sixth level of qualification in the Indonesian National Qualification Framework (INQF). Undergraduate student has to master the theoretical concepts of a particular field of knowledge in general and the theoretical concepts of special sections in that field of knowledge in depth, and be able to formulate the solution of procedural problems. In addition, graduate students must also be able to make the right decisions based on the analysis of information and data, and be able to provide guidance in choosing various alternative solutions independently. The skills that must be possessed by students who can support the achievement of learning based on INQF are metacognition skills.

Metacognitive (metacognition) is knowledge of one's own learning. It can be said that metacognitive skills are skills that a person knows how to learn according to himself. Metacognition is very important because it is in the form of knowledge about cognitive processes that can guide students in organizing and choosing cognitive performance. The process of metacognition is done by someone through one's own awareness. Metacognition activities occur when a person consciously adjusts and manages their thinking strategies when solving problems and thinking about a goal [3].

Metacognition is thinking about that consists of two components of knowledge and regulation. Metacognition involves three kinds of knowledge: 1) declarative knowledge about a learner's self, the factors that influence learning and memory, as well as the skills, strategies, and resources needed to do a task and know what to do; 2) procedural knowledge or know how to use strategy; and 3) conditional knowledge to ensure the completion of tasks when and why to implement certain procedures and strategies [4] [5].

Student metacognition skills can be trained and improved through the presence of student-centered learning activities. One of the student-centered learning activities is a project-based learning in the laboratory. Practical activities in the laboratory are able to bridge between theory and the real world in everyday life, and are able to help students develop their thought processes, scientific attitudes, and practical skills.

The natural product mini project laboratory provides opportunities for students to design their own activities to isolate secondary metabolites. Students design procedures to isolate secondary metabolites from plant samples that have not been reported in other natural product laboratory experiments [6].

Laboratory activities can improve the meaningfulness of natural product chemistry course. These laboratory activities can be useful for students from many different disciplines including chemistry, pharmacy, and medicine. Students at the third-year undergraduate level of chemistry education undertake the project to isolate secondary metabolites from medicinal plants. This project provides opportunities for students to design their own activities to isolate secondary metabolites from medicinal plants. Students were exposed to skills as extraction, fractionation, purification, and structural elucidation of secondary metabolites. In this project, two secondary metabolites successfully isolated from medicinal plants. The implementation of this project improved students' understanding of natural product chemistry [7]. This research aims to examine an application of the natural product mini project laboratory in order to improve the students' metacognitive.

2. Research Method

This research was a type of Ex Post Facto research, a systematic empirical study in which researchers do not control the independent variables directly because the embodiment of these variables has occurred or because these variables can not be manipulated.

The subjects in this study were students of chemistry education study program in the 6th semester of the 2019/2020 school year, Faculty of Teacher Training and Education, University of Mataram, which programed Natural Chemistry courses consisting of 50 people divided into 2 classes, namely class A and class B.

Structure of the natural product mini project laboratory consist of 1) Laboratory activities training, 2) Orientation problem (Students were given the problems. Each group worked on one plant sample). Plant samples consist of the rhizome of *Curcuma xanthorrhiza*, the rhizome of *Kaemferia pandurata*, the fruit of *Piper nigrum*, and the rhizome of *Kaemferia galanga*, 3) Designing laboratory activities (Students undertook a literature review of various sources and made proposals for experiments), 4) Presenting proposal of laboratory activities (Students communicated proposals to the other groups through a presentation), 5) Implementation of laboratory activities (Students implemented their proposal and collected data from sample preparation, extraction, fractionation, and purification of secondary metabolites), 6) Results reporting & presentation (Students made a report of their investigation and communicated it to other groups through presentations), 7) evaluation of the laboratory activities and analysis of the complex concepts (Students evaluated the laboratory activities that have been performed. Students infer complex concepts from information that has been obtained during laboratory activities such as secondary metabolite nomenclature, common properties of secondary metabolites, characteristics of secondary metabolite structures, separation of chemical components, and identification of secondary metabolite structures).

The instruments used were the Metacognition Skills Questionnaire developed by Scraw [4]. The questionnaire contained 52 items of "true" or "false" state-

ments containing indicators of metacognition skills. The validity of the instrument was determined by using content validity experts. Data processing was done by calculating the normalized gain scores and test two mean differences (t test or Mann-Whitney test).

3. Discussion

3.1. Application of Mini Project Laboratory

The implementation of mini project laboratory is aimed to reduce the application of expository methods in natural product chemistry learning. The process of applying a mini project laboratory can improve student metacognition. The metacognition indicator that most often appears during the implementation process is the planning indicator. This is shown by the results of student practicum proposals which most of them have displayed plans that are in accordance with the references they propose and there are innovations that they show both in the procedures and the tools and materials they will use. Then for the indicator with the lowest percentage occurrence is an indicator of monitoring ability. The low ability of student monitoring is indicated by there are several groups of students whose final project results did not get the planned secondary metabolite compound due to an error during the practicum process. Percentage data of observations on the appearance of metacognition skills indicators when applying the mini project laboratory model can be seen in Figure 1.

3.2. Students' Metacognition Skills

In general, students metacognition skills can be seen in Figure 1.

From Figure 2, it can be seen that the percentage of metacognition skills of students in general has increased to 58% for those in the high metacognition

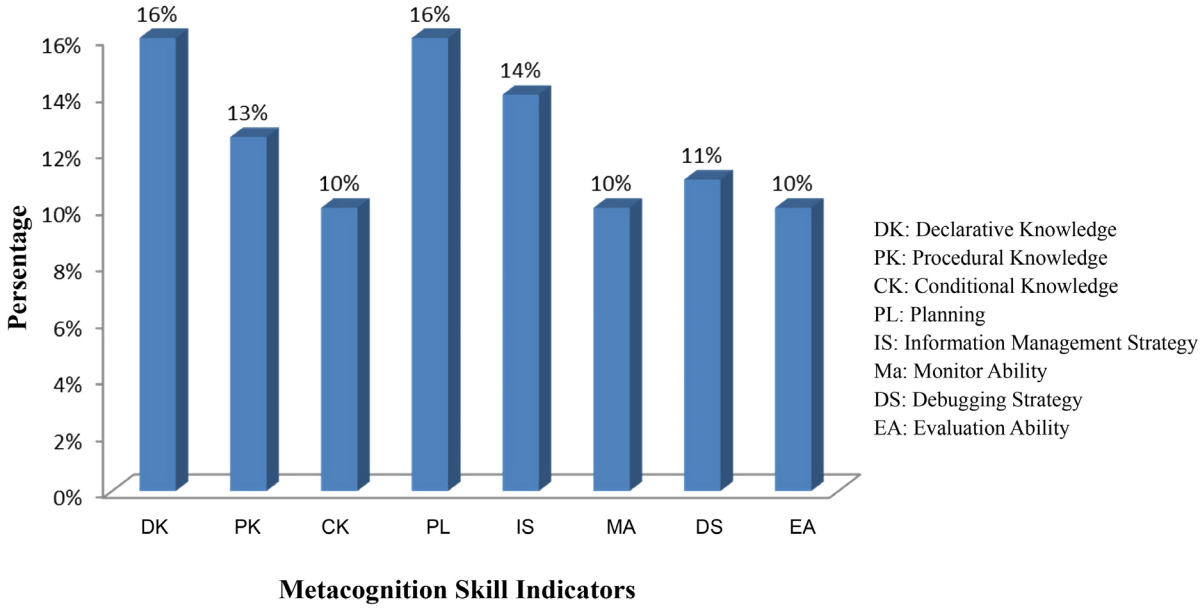

Figure 1. The Persentage of result of metacognition skill.

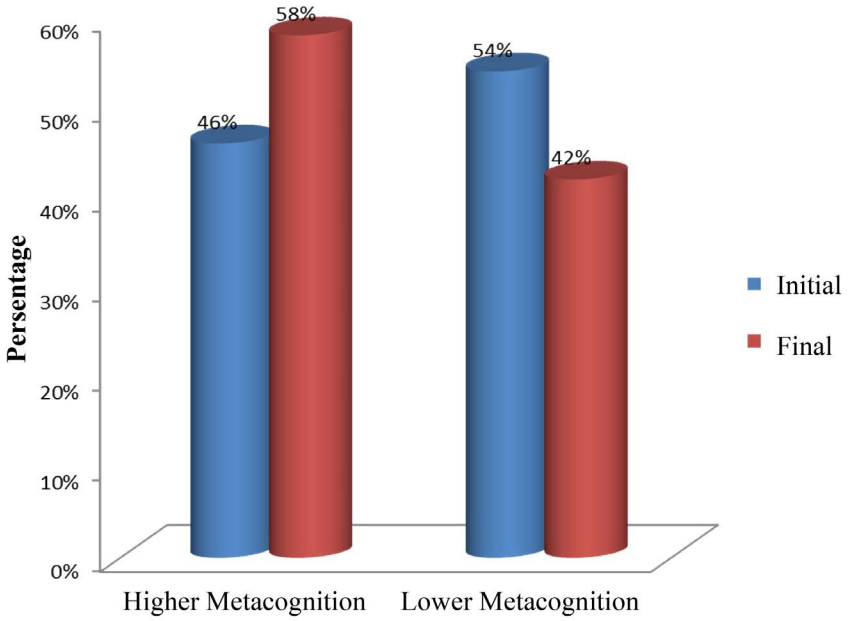

Figure 2. Student metacognition skills profile.

category group. This shows that after the application of the lab model of natural product chemistry mini project, there was an increase in students' metacognition skills. In other words, the lab model of the mini project of natural product chemistry was able to facilitate students to develop metacognition skills. The results of Caliskan & Sunbul's research revealed that the use of learning models and strategies influences students' metacognition skills [8]. Sastrika said that project-based learning model refers to the philosophical constructivism which states that in the learning process, students could construct their own knowledge and meaning through real experience [9].

Project-based learning accustoms students to think critically and creatively in dealing with problems in real projects [10]. Metacognition itself requires students to have high critical thinking skills too, so that if students' critical thinking skills are high then the students' metacognition skills will also be high [11]. Hakim, *et al.* also said that the mini project laboratory of natural product chemistry model could develop students' critical thinking skills [7]. The increase in the percentage of students' metacognition skills after the application of the learning model was also supported by the results of the analysis of N-gain values which showed an increase in the high category with N-gain mean of 0.73. Based on cognitive abilities, students' initial metacognition skills can be seen in **Figure 3**.

From **Figure 3** it was found that in the group included in the category with high Grade Point Average (GPA) had high metacognition skills too. This can be seen from the percentage of those who have high metacognition and high GPA before applying the learning model of 38%. This shows that students with high GPA mostly also have high metacognition skills. This is also consistent with research conducted by Muhlisin that students with high GPA have higher metacognition skills compared to students who have lower GPA [12]. Putri also ex-

plains that the lower the metacognition skills a person has, the lower the awareness means to monitor cognitive abilities, so they will not be able to develop cognitive abilities [13].

Figure 3 also shows that the final metacognition skills of students in the high GPA category group increased to 48% when compared to the metacognition skills before the application of the learning model of 38%. This shows that the learning model was able to facilitate students with high GPA to develop their metacognition skills. This also corresponded to the N-gain mean value of metacognition skills that were included in the high category. The results of Coutinho also said that there was a positive relationship between metacognition skills and student GPA [14]. Students who had a high GPA also had better metacognition skills compared to students with low GPA. The results of the correlation analysis between metacognition skills and student cumulative achievement index also found that there was a significant relationship between the GPA and metacognition skills.

Students' metacognition skills per indicator can be seen in Figure 4.

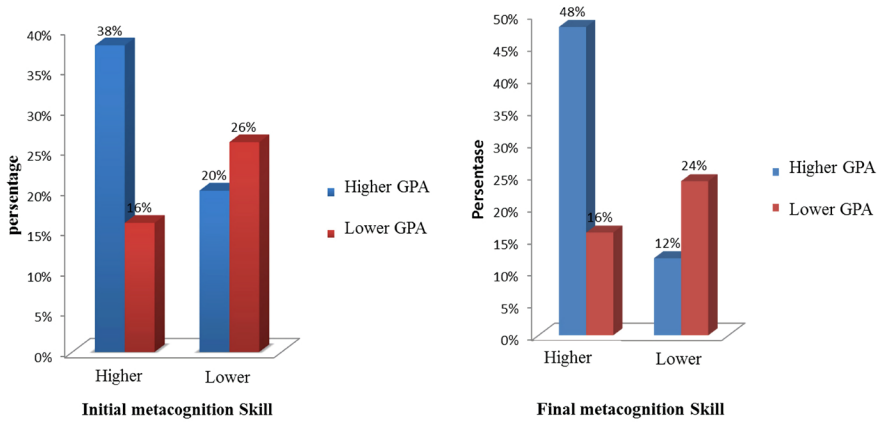

Figure 3. Profile of metacognition skills based on cognitive abilities.

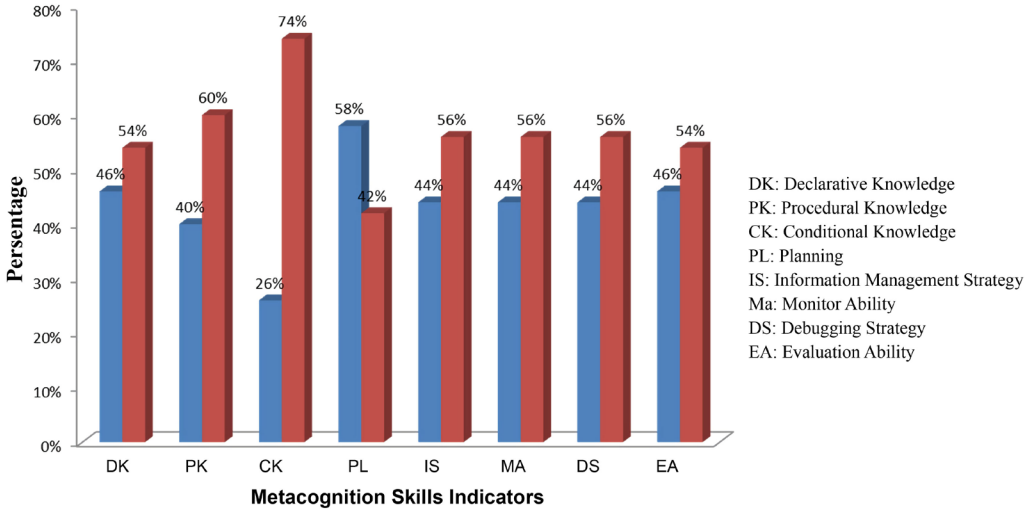

Figure 4. Student metacognition skills profile per indicator.

Based on Figure 4, it was found that the percentage of planning metacognition indicators (PL) had the highest percentage of high categories namely 58%. This shows that among all the indicators of metacognition skills, most students have good planning. Proven by before the learning model was done with students submitting a mini project laboratory proposal plan with good procedures and relevant references. The indicator that has the lowest percentage was the conditional knowledge (CK) indicator. This is evidenced by the majority of students not knowing how conditional when practicum and using practicum tools. However, from the way they used the tools and their place of practicum, it was seen that they did not have the conditional knowledge about how to use and how good conditions to do the practicum using column chromatography tools. The results of Paidi also suggest that students' understanding of matters related to declarative knowledge is still more dominant than their thoughts related to procedural knowledge, and also conditional knowledge [15].

4. Conclusion

Students' metacognition skills profile after the application of mini-project laboratory of natural product chemistry model had increased. Students with high GPA also had a high metacognition skills profile.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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