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ENABLING INDONESIAN PRE-SERVICE TEACHERS TO DESIGN BIOLOGY LEARNING TOOLS USING METACOGNITIVE STRATEGY

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ABSTRACT

Pre-service biology teachers are required to be able to design innovative learning tools, which include lesson plans, student worksheets, and assessment. Metacognitive strategy, along with the assistance of Self Understanding Evaluation Sheet (SUES), could be considered to help them construct the learning tools. This study intended to train pre-service biology teachers' skills in designing biology learning tools. It employed a one-shot case study design with 36 biology pre-service teachers at Universitas Negeri Surabaya, Indonesia, involved as participants. The implementation of the metacognitive strategy included revealing pre-service teachers' prior knowledge, determining confidence, writing new knowledge, contrasting the prior knowledge with the new knowledge, and evaluating their understanding using the SUES. Results showed that all pre-service teachers were skillful in designing biology learning tools, of which the scores given by the lecturer and themselves showed the insignificant difference. Another finding portrayed that the pre-service teachers provided positive feedbacks as a response to the implementation of metacognitive strategy during the learning process in designing biology learning tools.

Keywords: biology, learning tools, metacognitive strategy, SUES

INTRODUCTION

Innovative Learning I (IL I) is a compulsory pedagogical course at Biology Education Department, Universitas Negeri Surabaya, Indonesia. This course is essential for pre-service biology teachers because it provides experience for the students to develop learning tools then practice them with their peers. This experience is essential when they graduate and become a biology teacher. Furthermore, it also includes studies of several learning models involving direct instruction, discussion, concept attainment model, and learning strategies. The course begins with a theoretical explanation, modeling along with the examples of learning tools that applied for specific learning models, and workshop in developing the learning tools. The last part of the course is the implementation of a specific learning model in a peer teaching forum that covers discussion and reflective activities.

The pre-service teachers will pass the IL I course only if they can design learning tools in a relevant way to the learning models which the lecturer has taught previously. Designing the learning tools is one of the teacher's responsibilities to prepare, control, and conduct an excellent teaching and learning process (Janssen &

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Driel, 2017; Sergis et al., 2019; Shaikh & Khoja, 2012; Whitaker, 2017). One of the most familiar learning tools is a lesson plan, which comprises identity, goals, materials, learning procedures, learning sources, and assessment (Cherasaro et al., 2015; De Witte et al., 2015; Surgenor, 2010). Moreover, Kubilinskiene & Dagiene (2010) denoted that a lesson plan is a methodological and essential component in conducting a teaching and learning process. That is, it might be seen as one example of learning objects (Wiley, 2000).

Another important thing in learning tools is student worksheets and assessment. It is better for teachers to create student worksheets to control the authenticity and relevance of the contents toward the learning objectives settled in the very first beginning (Brown, 2001; Whitaker, 2017). Then, they need to develop an assessment sheet or rubric to measure whether or not the planned learning process is successful in achieving the objectives (Surgenor, 2010; Whitaker, 2017). Henceforth, the full set of learning tools covering lesson plan, student's worksheet, and assessment are obligatory to be well-designed (De Witte et al., 2015; Janssen & Driel, 2017).

Before applying the metacognitive strategy, the pre-service teachers were less skillful in constructing learning tools. Most of the case was the fact that they only did copy-paste from the internet without further engagements on processing the materials. For instance, they did not change the contents of the downloaded materials, or in other words, they did plagiarism. Moreover, the lecturer did not teach the method or the materials they downloaded. These tragic phenomena should be immediately taken into action by giving them meaningful experiences to be able to make biology learning tools. One of the learning strategies that can be used is a metacognitive strategy.

The researcher expected that after the pre-service teacher receives the metacognitive skills, they are able to design the learning tool by themselves. Metacognitive is a process of thinking, monitoring, regulating, and controlling the cognitive process (Roger et al., 2011). Metacognitive control is a regulatory model toward one's cognition that results in raising awareness of one's comprehension or understanding (Haryani et al., 2018; Karpicke, 2009). Most scholars suggest several activities such as planning, monitoring, and evaluating, all can be done during a learning process (Hacker et al., 2009; Whitebread et al., 2009). Hattie & Donoghue (2016) also confirmed that the abilities to break down, control, monitor learning strategies, and own metacognitive strategy become the factors in determining a successful learning process.

This research has a distinctive character when compared with other prior ones, as in this study, the metacognitive strategy was used in teaching the development of biology learning tools while the other previous research applied the strategy on a limited aspect such as in listening metacognition (Tanewong, 2019) and for academic achievement performance (de Boer et al., 2018). Moreover, the metacognitive strategy was integrated with Self-Understanding Evaluation Sheet (SUES) (Susantini et al., 2018a). With this in mind, this study aimed at (1) training pre-service teachers' skills in constructing biology learning tools; (2) contrasting scores of the produced learning tools given from lecturer and pre-service teachers; and (3) describing pre-service teachers' responses after using metacognitive strategy.

METHODS

This study used a pre-experimental design with a one-shot case study (Tuckman & Harper, 2012). The action was done during a learning process using a metacognitive strategy. The pre-service teachers' learning attainment was measured from how skillful they constructed biology learning tools, assessed the learning tools made by their peers, and gave responses toward the learning process. This study was conducted in Biology Education Department, Universitas Negeri Surabaya, Indonesia. 36 pre-service teachers studied biology education in the fourth semester took part in this research. They never got experience in constructing learning tools entirely, but had experience in designing assessment sheet in their previous semesters. The obtained data were analyzed using a descriptive quantitative, and qualitative approach.

The Self-Understanding Evaluation Sheet (SUES) was used in each meeting. Besides, there were five stages involved in the research procedure namely stating the pre-service teachers' prior knowledge, determining confidence, stating the latest obtained knowledge, contrasting between the prior and the latest knowledge, and giving scores toward self-understanding or comprehension. The IL I course was conducted in fifteen meetings consisting of three times delivering the learning model which each model has the sequence as follows; (1) the first meeting covered discussion of the learning models theoretically; (2) the second meeting included modeling includes the examples; and (3) the third meeting included the implementation of a workshop in designing the biology learning tools. Then, one meeting to have a mid-term exam and for the last five weeks, the students were asked to teach the learning models towards their friends or peer simulation. In this study, the pre-service teachers were asked to choose biology materials relevant to the learning model taught by the lecturer. As an independent assignment, they were obligatory to make learning tools based on the previous materials chosen by themselves.

Every aspect of learning tools constructed by the pre-service teachers was based on *Permendikbud* Number 24 the Year 2016. The aspects always began by stating the goals of conducting research. Moreover, the pre-service teachers were allowed to score their designed learning tools as the learning product. There were ten indicators for assessing the product with scores ranging from one to four.

It was expected that by using the metacognitive strategy, the scores given by the lecturer and pre-service teachers were insignificantly different. The difference in scores was revealed by calculating scores given by the lecturer and by the pre-service teachers. Four scoring categories then confirmed the results of the calculation. Score 4 was categorized as very good, only given if the score difference was in a range of 0 to 3. Score 3 with good category was given if the score difference was in a range of 4 to 7. Score 2, categorized as fair, was given if the score difference was in a range of 8 to 10, while score 1 was classified as bad if the score difference was more than 10. In every meeting, the pre-service teachers were asked to write down their responses using SUES, of which the responses were further analyzed qualitatively.

RESULTS AND DISCUSSION

In this section, there are several explanations concerning the skills in constructing biology learning tools, scoring skills toward the developed biology learning tools, and responses given by the pre-service teachers during the whole learning activities using the metacognitive strategy.

Skills in Constructing Biology Learning Tools

Most pre-service teachers were successful in constructing biology learning tools after using the metacognitive strategy during the teaching and learning process (see Table 1).

Table 1. The Frequency Data of Pre-Service Teachers' Scores in Designing Learning Tools during Innovative Learning I Course

No.	Scores	Frequency	Percentage (%)
1.	85-100	10	27.8
2.	80-84	9	25.0
3.	75-79	10	27.8
4.	70-74	6	16.6
5.	65-69	1	2.8

The implementation of the metacognitive strategy was aimed to make the pre-service teachers recall their prior knowledge and then relate them to the correct concepts they obtained from what they just learned in class. Naturally, such implementation was able to widen their knowledge. Besides, the pre-service teachers needed to engage with when and how to use diverse learning strategies and the reason underlying the selection of a particular approach. Thus, they were not stuck in a stage of knowing what learning strategies must be used for declarative knowledge and how to use procedural knowledge only (Hattie & Donoghue, 2016; Peteranetz, 2016).

Metacognitive skills should be taught and trained for the pre-service teachers to grasp the skills. Specifically, in how to use the learning strategies (Karpicke, 2009; Peteranetz, 2016; Sisquiarco et al., 2018). The application of metacognitive strategy, in this study, was assisted by the use of SUES, which guided pre-service teachers to comprehend metacognitive strategy, including the use and the self-understanding toward the given materials. A teaching and learning process integrated with metacognitive must be delivered explicitly (Haryani et al., 2018; Karpicke, 2009; Peteranetz, 2016). In other words, the learning process should begin with the implementation of modeling or lecturer's strategy, then followed by structural opportunities that let pre-service teachers to practices and use the skills (Peteranetz, 2016). The lecturer should give feedbacks to strengthen the use of the strategy (Juwah et al., 2004; Sutton et al., 2010; Wiliam, 2013;) and correct or conduct remedial teaching if the implemented strategy was inappropriate or out of what has been expected (Luoch, 2016; Oyekan, 2013). OECD (2016) suggested that an excellent cognitive teaching strategy should at least (1) expect students to explain their thinking on complex problems; (2) encourage students to solve problems in more than one way; (3) require students to provide written explanations of how they the

solve problems; and (4) encourage students to work together to solve problems.

Another critical aspect is giving pre-service teachers chances to practice. Those who are severe in developing strategy autonomously should be helped to get a more straightforward form of understanding the strategy. Even though a lecturer can help to overcome such problem; pre-service teachers should do an independent exercise in applying the strategy and responding to the lecturer's feedback, which will lead to better learning habituation. This stage is indeed relevant to the implementation of the metacognitive strategy with SUES.

An excellent teaching of learning strategies should (1) improve pre-service teachers' performance especially for those who have not developed practical metacognitive skills; (2) enhance pre-service teachers' independence and their affection toward teaching and learning process; and (3) make pre-service teachers conscious of ineffective strategy that hampers their performance and ability (Schunk & Greene, 2017). Table 2 depicts the average scores of the ten indicators portraying pre-service teachers' skills in creating learning tools, of which all indicators showed scores of ≥ 3, which were considered in a good category. In other words, all pre-service teachers had excellent skills in designing appropriate learning tools. However, they were also required to enhance their skills in designing biology learning tools especially in providing the full set of learning plans, time allocation, and assessment tools since those three indicators showed the least scores compared to other indicators (see Table 2).

Table 2. Pre-Service Teachers' Skills in Creating Biology Learning Tools

Indicators	Average Scores*
Clarity of learning objectives (i.e., no ambiguity and focusing on learning outcomes)	3.3
Relevancy between learning materials, the learning objectives, and model used	3.36
Structured learning materials covering the orders, systematic materials, and appropriate time allocation	3.1
Learning sources that should be in line with the learning objectives, materials, and students' characteristics	3
Clear stages of learning activities (i.e., steps in learning Direct Instruction/Learning Strategy)	3.19
Detailed learning activities (i.e., each learning stage must be referred to the used strategy/ model and time allocation)	3.06
Relevant student worksheets with the learning objectives of Direct Instruction/Learning Strategy	3.4
Relevant answer keys of the student worksheets with the true concepts	3.2
Relevancy between assessment technique and the learning objectives	3.1
The availability of full-set assessment instruments	3

Concerning the lecturer's comments and suggestions, moreover, the pre-service teachers needed to determine appropriate time allocations (see Lecturer's Comment 1).

"*The time allocation is necessarily reconsidered since it is not well-distributed among subtopics of materials.*" (Lecturer's Comment 1)

After a more in-depth analysis towards the determined time allocation, the pre-service teachers used 150 minutes only for a sub-topic of blood circulation while the times should be used to include all the sub-topics in human's circulation system. Therefore, the lecturer suggested the pre-service teachers reconsider the given time allocation in order to cover all other sub-topics.

In connection with the lesson plan of categorizing types of algae, the lecturer recommended the pre-service teachers to add pictures of each algae type (see Lecturer's Comment 2). The student book used in the lesson plan made by the pre-service teachers did not accommodate pictures and only covered the characteristics of each algae type. However, the student worksheets developed by the pre-service teachers consisted of questions asking for identifying algae types in the form of pictures. According to the lecturer, those phenomena should not happen since lesson plan along with the student book and worksheets should accommodate the same learning indicators and materials, i.e., providing pictures of algae types.

"*All pre-service teachers are required to give pictures in the student book and worksheets to enable students to understand the taught concepts* easily." (Lecturer's Comment 2)

"*The assessment rubric is too long that can make the users confused.*" (Lecturer's Comment 3)

The Lecturer's Comment 3 showed that the pre-service teachers needed to pay attention to developing an assessment rubric of Biogeochemistry materials. The rubric was challenging to be understood and had several confusing and circular statements so that other people might get misled when using the rubric. The lecturer, further, suggested that the statements used in the rubric could be shortened in order to be easily understood by any teacher.

Skills in Scoring Biology Learning Tools

After the pre-service teachers constructed biology learning tools, the lecturer allowed scoring the results developed by themselves. In short, there were two scores; one score from the lecturer and the other one from the pre-service teachers. Such scoring procedure was aimed to train pre-service teachers to implement another aspect of metacognitive skills, namely an ability to do self-assessment, after getting accustomed to evaluate self-understanding.

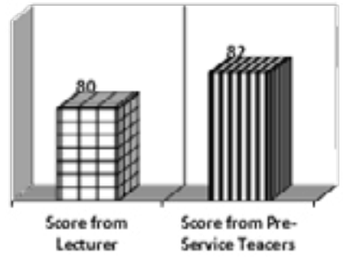

Figure 1. Average Scores Given by the Lecturer and Pre-Service Teachers.

The results of the average scores given by the lecturer and pre-service teachers are shown in Figure 1. The score gap was only 2, meaning that the pre-service teachers were able to assess the developed biology learning tools. The reason why the scores by the pre-service teachers and lecturer were slightly different was due to the fact that the instrument had been initially validated. Moreover, the pre-service teachers and lecturer made similar perceptions to interpret and use the instrument. Another rationale was because the lecturer always trained the pre-service teachers to perform self-evaluation in every meeting.

Table 3. Scoring Skills of the Developed Learning Tools.

Score Difference	Score	Category	Frequency	Percentage (%)
0-3	4	Very good	18	50.0
4-7	3	Good	12	33.3
8-10	2	Fair	6	16.7
>10	1	Poor	0	0.00

Table 3 shows that most pre-service teachers were categorized as 'good' and 'very good' in scoring biology learning tools. An ability to determine score is one aspect of metacognitive skills. In this case, pre-service teachers were successful in determining scores along with the understanding of self-capability. There was no difference between scores given by the lecturer and the pre-service teachers because the metacognitive strategy already trained the pre-service teachers in measuring their ability and comprehension toward themselves, also in building a high self-belief and confidence. This is in line with Zimmerman & Schunk (2011), who stated that an academically successful pre-service teacher is the one who accomplishes all learning assignments confidently and diligently, also, understands the required learning strategy. They are also conscious of which the knowledge and skills they possess (Wiliam, 2013). They are the ones who show a proactive approach to get information and define an exact pace of how to master knowledge. They know how to cope with learning obstacles such as lousy learning situation, confusing lecturer's explanation, or difficult book to understand. Moreover, they believe that learning is a systematic and restrained process that should be carried within a firm responsibility in order to achieve the settled goals (Alsubaie, 2016). Pre-service teachers perceive metacognitive strategy, motivation, and active participation in their learning process; and referring to Schunk, & Greene (2017), pre-service teachers with high metacognitive strategy can plan, determine goals, manage information, and gradually yet persistently evaluate their progress.

Pre-Service Teachers' Responses toward the Conducted Learning Activities Using Metacognitive Strategy

Pre-service teachers' responses toward the implementation of the metacognitive strategy were obtained from SUES that was always given at the end of each meeting. The pre-service teachers wrote their impression and suggestion toward the implemented teaching and learning process. Furthermore, to cope with that, the following significant responses were depicted to reveal how

pre-service teachers fell about the learning process.

"*SUES helps me find essential concepts that should be learned, and it can be applied in a learning process, especially in particular materials that are often sensitive to misconceptions.*" (Pre-service teacher 1)

"*This learning process assisted with SUES is delightful because I can assess my understanding of a certain concept. Moreover, this is also helpful to know my learning progress, from what I knew previously and what I have just got lately.*" (Pre-service teacher 2)

"*By using a metacognitive strategy, I can assess my understanding of learning models and at the same time, ease me to know the fundamental concepts of diverse learning models. I also know how to implement the correct implementation of different learning models and how to construct a good learning tool.*" (Pre-service teacher 3)

Generally, all pre-service teachers responded positively, such as they could assess their understanding and eased to know essential concepts. They also had excellent self-regulation to consciously control and choose an appropriate strategy which then made them perceive high metacognitive skills. Hattie (2009) describes that pre-service teachers who have self-regulation are those who likely become good teachers because they have known various strategies that can be implemented in facing any learning obstacle. Moreover, they have a clear concept of succeeding in a specific assignment (Janssen & Driel, 2017). Ocak & Ahmet (2013) and Susantini et al. (2018b) state that the use of an effective strategy is essential and have a positive way of achieving better learning attainments.

CONCLUSION

Some conclusions can be retracted from this study. First, the metacognitive strategy can train pre-service teachers to design biology learning tools. Second, there was no significant difference between the score given by lecturer and the pre-service teachers; therefore, the pre-service teachers are categorized as skillful in assessing learning tools. Third, the pre-service teachers provided positive responses to the implementation of the metacognitive strategy with SUES. They argued that it eased them to assess their understanding and knowledge of several important concepts. Nevertheless, in bringing the pre-service teachers' skill to a more advanced level, workshops on modeling and creating learning tools sound essential to be undertaken sequentially.

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