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Quality Improvement on Chemistry Practicum Courses Through Implementation of 5E Learning Cycle

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Abstract. Two of bachelor of chemical education's competences are having practical skills and mastering chemistry material. Practicum courses are organized to support the competency achievement. Based on observation and evaluation, many problems were found in the implementation of practicum courses. Preliminary study indicated that 5E Learning Cycle can be used as an alternative solution in order to improve the quality of chemistry practicum course. The 5E Learning Cycle can provide positive influence on the achievement of the competence, laboratory skills, and students' understanding. The aim of the research was to describe the feasibility of implementation of 5E Learning Cycle on chemistry practicum courses. The research was based on phenomenology method in qualitative approach. The participants of the research were 5 person of chemistry laboratory manager (lecturers at chemistry and chemistry education department). They concluded that the 5E Learning Cycle could be implemented to improve the quality of the chemistry practicum courses. Practicum guides and assistant competences were organized to support the implementation of 5E Learning Cycle. It needed training for assistants to understand and implement in the stages of 5E Learning Cycle. Preparation of practical guidelines referred to the stages of 5E Learning Cycle, started with the introduction of contextual and applicable materials, then followed with work procedures that accommodate the stage of engagement, exploration, explanation, extension, and evaluation

INTRODUCTION

The Competence of Chemical Education and Chemistry Department bachelors at Islamic University of Indonesia are having laboratory skills and mastering chemistry materials. Practicum course was organized to support the achievement of these outcomes. Practicum course was firstly given in first semester. Chemical indeed cannot be separated from laboratory activities. Chemistry is having developed by experiment. Practicum course is absolutely necessary to prepare students with laboratory skill and a comprehensive understanding of the chemical knowledge.

The Implementation of practicum course is very important in order to support the bachelor' competence. Practicum course is a tool to strengthen and prove a theory obtained through lectures in the class. So that, it was expected that bachelors are not only have competence in the real of knowledge, but also performance. Based on the observation and evaluation, several problems are encountered and it must have alternative solutions in the implementation of practicum course. The evaluation showed that laboratory skill and the comprehension of students in the chemical material is still low, although they have joined practicum course [1]. This is due to several causes below: 1) the laboratory work done by the students is uneven, not all students are actively doing practicum work procedures. There are students who only contribute equipment and materials, do a little work procedures. 2) The practicum guidebook has not been effective to help students understand the purpose, basic, and practicum data analysis. This is because the guidelines are not contextual, so the student is difficult to grasp the meaning of practicum. 3) The students (who practice) do not understand the urgency of practicum courses. 4) The Students do not know the practicum application which is done in the world of work, so that the interest to understand the basic principles of experiments conducted tends to be low.

From the causes above, it need efforts to improve the organization of practicum courses. One of the efforts that have been made is by applying 5E Learning Cycle (5E LC). 5E LC is appropriate to be applied in the chemistry

practicum, because 5E LC is firstly designed for science learning. The Preliminary research shows that the application of 5E LC can improve laboratory skills, understanding of chemical material, interest, and the positive response of students [1]. There is a generating interest stage in 5E LC, which it is different from conventional practicum. The stages in 5E LC also requires students to actively conduct experiments independently, clarify and apply the concepts learned in the experiment continued. 5E LC evaluation phase in 5E LC minimize misconceptions and improper performance. This study focused on describing the feasibility of applying 5E LC in chemistry practicum courses.

LITERATURE REVIEW

Learning cycle is a learning model that was originally developed by Robert Karbles in 1960. The learning cycle implements more in science learning. Several studies conducted to describe the effectiveness of the learning cycle implementation. The implementation of learning cycle gives positive influence on the understanding of scientific concepts, perspectives and attitudes towards science. Learning cycle continues to be developed until 1993. The Biological Science Curriculum Study (BSCS) enhanced the learning cycle stages into 5 stages[2] and it is known as 5E LC. The stages in LC include: 1) Engagement, engagement is the phase of generating interest and curiosity. At this stage it is necessary that the students prepared and conditioned for researching a topic or material. The strategy used are giving contextual questions, connecting prior knowledge with new material to be studied, and defining the problem, delivering the material linkages with life. At this stage, the students are directed to seek answers to the question at the core of experiments to be performed. 2) Exploration, at this stage, students are given the opportunity to work together in small groups to conduct experiments, test predictions, make observations, collect and analyze the data to make conclusions to answer any questions that arise. Exploration stage is a stage that can cause disequilibrium situation. According to the theory of constructivism and cognitivism, the learning process starting from a situation of doubt due to differences in cognitive scheme which has been owned by the new situation. This will stimulate further thought until students feel like they have a cognitive intact scheme. 3) Explanation, students are asked to explain the concept and describe the results of the experiment. The purpose of explanation stage is complete, enhance and develop the concept that acquired by the student. Assistants and lecturers explain the concept, show the examples that related to concepts, deepen the relationship between variables, and add the conclusions obtained by the student. 4) Extension or Elaboration, the essence of this stage is to expand and apply the concepts and skills that have learned by the students in new situations. The objective of the extension phase is to increase the understanding and ability of students. At this stage it can be done through an advanced practicum or observation. 5) Evaluation, the evaluation is conducted through knowledge, understanding concepts, competencies acquired in the previous stages. The evaluation was conducted by lecturers, assistants, and students. Evaluation covers student competency of activities that have been carried out. Students can do a self-evaluation by asking open-ended questions and seek answers through observation, evidence and explanations obtained. Students also evaluated the strength and weakness of their selves in the learning process that has been done[2,3].

Brown and Abell conducted a study of research conducted over the past 40 years, and concluded that the application of 5E LC can increase engagement, reasoning, and comprehension in science classes[3]. 5E LC also enrich the learning and scientific experience that gives more real[4]. 5E LC is an effective hands-on and inquiry-based scientific pedagogy that enhances students' scientific knowledge and understanding[5]. LC facilitate students to learn effectively, organize knowledge significantly, test prior-knowledge possessed, overcome disequilibrium between initial concept owned by the facts, so that students are trained to build knowledge[6,7]. 5E LC provides a good performance of laboratory activities, because 5E LC provides an opportunity to associate with the prior knowledge of the studied materials and interest in conducted experiments[8].

RESEARCH METHOD

This study used a qualitative research approach with phenomenological method, which it is the use of life experience as a tool to understand the object of research. The study aimed to describe the feasibility of 5E LC implementation in chemistry practicum courses such as organic chemistry practicum, inorganic chemistry practicum, chemistry physics practicum, basic chemistry practicum, and biochemistry practicum. The Respondents of the research are 5 people, which are the manager of a chemical laboratory. The Respondents are also lecturer of chemistry practicum course. The selection of respondents is based on the consideration of the expertise aspect and the experience in teaching at chemistry practicum course. The data collection technique are open discussions,

personal interviews, and questionnaire on the applicability of 5E LC. Information obtained from the respondents used to describe the feasibility of 5E LC implementation.

RESULT AND DISCUSSION

Data questionnaire covers four main aspects, namely: 1) the main practicum problem, 2) the feasibility of applying 5E LC, 3) the benefit of 5E LC, 4) the ease of 5E LC implementation, 5) the suggestions for improvement. This study used open Questionnaires, where respondents are free to write the response of each statement. The following data questionnaires are: 1) all respondents said the quality of the practicum needs to be improved. Problems in the practicum include the low achievement of students in laboratory skills and understanding of the material, the interest of students, not to equip students with life skills, trial impressed not applicable; 2) all respondents stated 5E LC feasible as an alternative solution; 3) stages in 5E LC, if applied by all respondents have a positive effect for students. All respondents gave a positive response on the stage 5E LC, especially the stages of generation; 4) 3 respondents said that 5E LC is easy to implement. 2 respondents generally think 5E LC is easy to implement, but the challenge of implementation is the competence of assistant and time allocation. The competence of assistant must be prepared to understand the stage of 5E LC and master the experiments concept. Assistant must be able to manage time, so that the allocation for 120 minutes is enough to apply the stage of 5E LC; 5) 2 respondents expressed the need for setting up assistant the assistant competence, 2 respondents expressed the need for practical guidelines which accommodates the stage of 5E LC, 1 respondent expressed the need for simulation 5E LC by assistant in order not to exceed the existing time allocation. The competence of assistant is needed especially at the stage of generating interest and evaluation. In conventional practicum, the assistant does not perform the generation of interest. It need to setup assistant competencies in order to understand the ways to generate interest of students, one of them through examples of applications of everyday life and the urgency of the experiment. Assistants also must master the trial concepts completely in order to evaluate if an error occurs and the concept of performance done by the students.

The personal interviews data and open discussion does not contradiction with the questionnaire data. Respondents viewed that the organization of the chemistry practicum course requires a process quality improvement efforts. The generation of interest, deepening the concepts and laboratory skills are the main problems in the chemistry practicum course. In general, the respondents said that 5E LC is feasible. It need to setup several aspects in order 5E LC can be held properly which it is by the competency of assistants and practicum guides based on 5E LC. The competencies is needed for practicum assistants in order to make the practicum can be implemented according to the stages 5E LC and in accordance with the allocation of time provided.

Based on the data above, it can be described that the implementation of 5E LC can be used as an alternative solution to improve the quality of chemistry practicum course. The suitability of 5E LC can be viewed from two aspects; the positive impact that can be caused and the ease of 5E LC phases. 5E LC is suitable to be applied to the subject using a scientific approach. Stages in 5E LC facilitate students to actively conduct experiments according to the steps of the scientific method. Besides, the engagement stage encourages students to be interested in the experiments to be performed. The practicum assistant and the lecturer started the practicum by asking a question that can attract students. Questions can also be directed prior knowledge of students in the core experiments to be performed. The generation of interest was to be crucial for the respondent.

According to respondents, generating interest is the main and the first thing to do for starting practicum. However, the obstacle is the lack of practicum assistant to generate the interest. Assistants may not be able to provide the questions or exposure to arouse the interest of students. The solution is to do with the provision of practical guidance in context. The practicum guidance can be preceded by an introduction about the benefits and the application of experiment concept to be performed in daily life. Lecturers can also provide provisioning to the assistant to reinforce the concept and application experiments.

In addition to generating interest, practicum with 5E LC model also facilitate students to conduct scientific activities. This is in contrast with practicum implementation that usually done. Practicum implementation begins with a pre-test. The Regulations of Chemical Laboratory Coordinator, pre-test score should be at least 60, if less, students are not allowed to follow the practicum. At the practicum that had been held, the assistant corrected the pre-test and the student conduct experimental work procedures. This method needs to be evaluated because some students were not interested in experiments to be performed. Students only limited to do the work procedures without knowing the urgency of the experiments performed. The learning process will not be optimal without any interest. On the implementation of 5E LC after the pre-test, the assistant gave an introduction and contextual

questions to arise the interest and curiosity of students. Questions given by the assistant direct the students to find answers to the problems corresponding experimental purposes. The Generation of interest can be further conditioned the students to construct knowledge through practicum to be done. In line with the theory of constructivism, knowledge is built through real experience. Students did the practicum in accordance with available procedures. Exploration stage in 5E LC, students are given the opportunity to work together in small groups to conduct experiments, test predictions, make observations, collect and analyze the data and make conclusions to answer questions. In the practicum, students work with chemicals that can be dangerous if it has not appropriate handling. Thus, in the exploration stage, the assistant monitor student's work in order to not deviate from the subject and remind students who did not work with a correct procedures or inappropriate chemicals treatment. On conventional practicum, students did work procedures, but some students do not understand the purpose of the experiment that has been conducted. The lack of interest causes students to do the work procedures without understanding the purpose of the experiment.

The next stage is explanation. In this stage, the students clarify the results, the assistant complete the result and confirm if there are less precise concepts and procedures including the use of tools and materials. This helps the student in terms of understanding the concepts and laboratory skill mastery. Students can learn the proper use of tools and the concepts of experiments have been conducted. In conventional practicum, students only focus on completing the work procedures. Assistants are often not correct the student when they use less precise laboratory instruments. In addition, there is no chance for the students to explain the results obtained. However, the explanation stage can reduce the chances of misconceptions.

Furthermore, students expand and apply the concepts and skills they have learned in new situations (extension). The purpose of this phase is to increase the understanding and the ability of students. The activities are an advanced practicum in the new situation that more complex. Advanced Practicum can deepen understanding and improve the student's laboratory skill. On conventional practicum, there is no an advanced practicum stages, the working procedures do not distinguish between basic and advanced practicum.

At the end of the practicum, there is an evaluation. The evaluation was conducted through knowledge, concept understanding, and competencies acquired in the previous stages. The evaluation was conducted by lecturers, assistants, and students. Lecturer and assistant can evaluate student's competency based on the activities that have been carried out. Students can do a self-evaluation by asking open-ended questions and seeking answers through observation, evidence and explanations obtained. On conventional practicum, the practicum implementation is oriented to the implementation of the trial, and less to give students an opportunity to assess and evaluate the ability of self. After completing the experiment, the assistant or lecturer simply direct the students to the way of data analyzing in order to make report and close the practicum. The summary description of conventional practicum and practicum-based 5E LC on table 1.

TABLE 1. the description of conventional practicum implementation and practicum- based 5E LC

Aspect	Conventional	5E LC
Introduction	Practicum started with pre-test	After the pre-test, the assistant provide contextual questions, connect the prior knowledge with new material to be studied, deliver the linkages material with life (engagement).
Practicum	Conducting work procedure	Perform work procedures (exploration), then students represent the results, assistant completes it and confirmed that there are concepts and work procedures that are less precise, including on the use of tools and materials (explanation). Applying the concepts and skills they have learned in a new situation or continued practicum (extension).
Closing	Explanation of data analysis method	Students represent the results, assistant completes it and confirmed that there are concepts and work procedures that are less precise, including on the use of tools and materials

According to 5 respondents, 5E LC method is eligible to be applied in chemical practicum. 5E LC stages were uncomplicated to do. However, it is necessary to prepare the assistant's competence. Assistants need to be equipped on stage in 5E LC, particularly at the stage of engagement. The assistant also need to be trained according to the 5E LC implementation. Then, the available time allocations in practicum is sufficient for the phases implementation in 5E LC. The availability of practicum contextual guide and stages accommodation in 5E LC is also necessary.

CONCLUSION

Chemistry practicum course implementation requires improvement. 5E LC is feasible in a chemistry practicum course. The Eligibility can be viewed from two aspects; the positive impact and the ease of implementation. However, the competence of assistants and practicum contextual guideline is indispensable. It is necessary to organize training for assistants in order to understand the phases in 5E LC. Practicum guideline is also necessary to be designed contextually and the phases accommodation in 5E LC is also need to be considered.

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