Needs analysis of the development of a mini laboratory model in the biochemistry instruction

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NEEDS ANALYSIS OF THE DEVELOPMENT OF A MINI LABORATORY MODEL IN THE BIOCHEMISTRY INSTRUCTION

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Abstract—This research aims to analyze the problems identified in the implementation of the Biochemistry laboratory work in Mataram University, the students' critical thinking skills through writing Biochemistry laboratory work reports, and the opportunity to develop a mini laboratory model for the Biochemistry instruction. The method used in this research is a quantitative method and questionnaires were used to collect data. The questionnaires were distributed to 105 students at Mataram University taking a Biochemistry course and to two Biochemistry lecturers. The analysis results were corroborated by the students' and lecturers' written comments and the analysis of the students' laboratory work reports. The research results show that the problems identified during the implementation of the Biochemistry laboratory work in Mataram University were, among others, that the students were not given enough opportunity to conduct a preliminary research, that the lecturers were not involved in the process of laboratory work and in giving feedback on the laboratory work results by means of presentation. The analysis of the Biochemistry laboratory work reports shows that the students had not developed their ability to think critically. This finding provides an opportunity for the development of a mini laboratory model which is integrated, unlimited to space, dynamic, and which provides ample opportunities to the students to present the results of their laboratory work.

Keywords: *Biochemistry, Laboratory Work, Mini Laboratory Model*

I. INTRODUCTION

Biochemistry is one of the compulsory courses that students must take in the Chemistry and Chemistry Education Study Program. Currently, the students' response to biochemistry shows that they find the materials difficult. Broman et al. [1] assert that biochemistry is the most difficult subject for students to understand and the most interesting subject of all at the same time. The research results corroborate the previous research conducted by the students at Mataram University taking Biochemistry Course. 90% of the students found Biochemistry course difficult, and 80% of the students stated their difficulty in learning Biochemistry II [2].

The difficulties that students encounter in Biochemistry are the concepts related to the abstract bodies of living beings, which are difficult to visualize, and need higher thinking skills [3]. The complex concept is related to the interconnectedness of the macroscopic, microscopic, and symbolic levels of thinking. The macroscopic level deals with the description of real phenomena which occur daily or which can be observed in the laboratory as an observation result or real evidence of their existence. Elucidation, the way to describe and make prediction related to the chemical nature and process can be explained through submicroscopic thinking. Symbolism covers signs used to communicate concepts and ideas [4].

Sirhan [4] reveals that the difficulties in learning Biochemistry are related to some factors such as the content of the curriculum, overlapping concepts, language problems and communication, and motivation. The curriculum of Biochemistry in the university level in Indonesia covers a very broad range of materials delivered through a relatively short period of instruction. The main Biochemistry materials cover protein, enzyme, nucleic acid, biosynthesis protein, structure and classification of carbohydrate, carbohydrate

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catabolism and anabolism, and triglyceride catabolism and anabolism. The wide range of materials delivered in a very short period of time leads to the use of lecturing as the best teaching method to deliver materials to the students. This method leads to the decrease of motivation and interest among the students to explore the materials deeper [5].

The laboratory work activity is one of the methods which can relate the macroscopic, microscopic and symbolic levels and is able to stimulate the students' interest and attention [6]. The laboratory work is also able to increase students' ability to make arguments as the center of development of knowledge an d science [7].

Biochemistry course has included laboratory work activities in the curriculum. The laboratory work manual written is sometimes only to fulfill the semester credit requirement without considering the content. This ineffectiveness of the laboratory work activity which does not fulfill the empirical aspect of learning is the main cause of students' difficulties, and is therefore unable to train students to develop their critical thinking skills.

Reid & Shah [8] propose a model of effective implementation of laboratory work. There are 4 stages, namely the planning stage to make chemistry more real, to train the ability to observe, deduce and interpret, and to develop basic practical skills. The pre-laboratory stage deals with presenting the goal of the experiments and planning the experiments to be done. The experiment stage gives freedom to the students in deciding the methods to conduct the experiment. The last stage deals with the application of learning in a wider context for evaluation. These four stages are described in Figure 1.

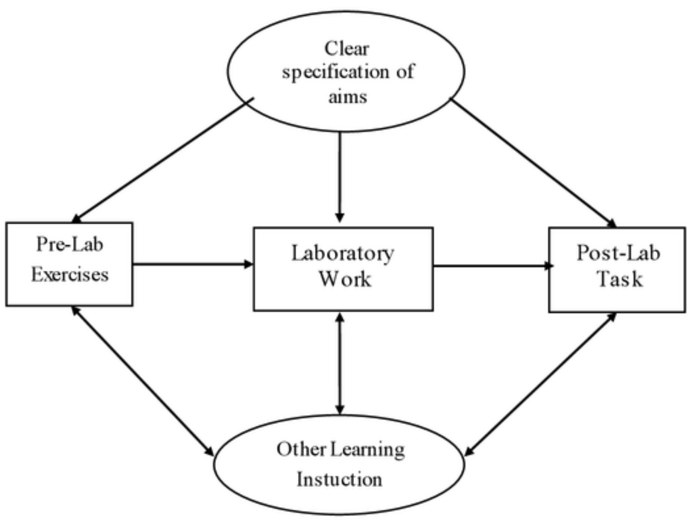

FIGURE 1. STAGES OF LABORATORY WORK IMPLEMENTATION [8]

The concept of mini laboratory using classrooms, library, and the surrounding environment involves students in problem solving. Mini laboratory can facilitate students in connecting different disciplines of knowledge as the basis to design a small or big experiment to develop students' creativity and experience [9,10].

II. METHODOLOGY

This research aims to (1) analyze the problems in the laboratory work implementation in the Biochemistry Course in Mataram University, (2) analyze students' critical thinking skills in writing Biochemistry laboratory work reports, and (3) analyze the opportunity for the development of mini laboratory model in the Biochemistry learning instruction.

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The research to identify problems in the implementation of laboratory work in the Biochemistry course in Mataram University was conducted using a quantitative method and questionnaires were employed as the data gathering technique. Two types of questionnaires were developed, namely a questionnaire for the lecturers of Biochemistry course and a questionnaire for the students of the Biochemistry course. The questionnaire items consisted of 5 indicators, such as the implementation of laboratory work in the Biochemistry course, lecturer's involvement in the implementation of Biochemistry laboratory work, the integration of the implementation of the Biochemistry laboratory work and face-to-face interaction in class, the implementation of the Biochemistry laboratory work in training students' critical thinking skills, relevance of the Biochemistry laboratory work to the students' needs and the feedback on the implementation of the Biochemistry laboratory work to the students' critical thinking skills. The questionnaire for the students consisted of 18 questions using a 4-itemLikert scale of *never, sometimes, often,* and *very often*. The questionnaire for the lecturers consisted of 18 questions using a 4-itemLikert scale of ranged expressions of *has never been implemented, has been discussed, has been planned to be implemented,* and *has been implemented*. After the questionnaires were validated by two experts in Chemistry education, it was found that only 16 items were qualified for the lecturer questionnaire and 17 items were deemed valid for the students' questionnaires.

The valid questionnaires were then distributed to the samples to fill in. The research samples were 54 students in the Chemistry Education Study Program, Faculty of Teachers Training and Education, and 51 students of the Chemistry Department, Faculty of Mathematics and Natural Sciences, Mataram University taking Biochemistry course. There were two Biochemistry lecturers.

III. RESULT

The results of the questionnaire analysis show that the problems and obstacles identified in the implementation of the Biochemistry laboratory work are (1) the laboratory equipments were not available, the Biochemistry laboratory work were not able to develop students' critical thinking skills, the feedback of the laboratory work results had not been best responded, the lecturer's involvement in the implementation of the laboratory work was not optimum. However, students gave positive responses to the relevance of laboratory work to their needs and the implementation of group work during the Biochemistry laboratory work in the laboratory.

From the analysis results of the students' answers, it was found that 61% of the students working well in a group work responded positively to collective laboratory work. Students felt that through laboratory work they had an opportunity to develop their interest in the Biochemistry course. The students responded quite differently to the integration of laboratory work materials and the theory discussed in the class. The students of Chemistry Education, FKIP, Mataram University taking Biochemistry course, gave a positive response to the integration of the materials being practiced and the theory they learned in the class. 55% of the students of the Chemistry Study Program, FMIPA, Mataram Unversity, stated that sometimes the laboratory work materials in the laboratory did not correspond to the theories they learned in the class.

Some 0.06% of the students felt comfortable working in the laboratory, some also felt that they did not understand and did not get clear explanation of the laboratory work procedures from the manual. Students felt that they found obstacles during the laboratory work caused by the unavailability of laboratory equipments. In terms of the implementation of laboratory work, the session did not start with the problems to be solved but they only worked according to the procedures in the laboratory work manual. Therefore, the implementation of the Biochemistry laboratory work was mostly like a cookbook laboratory experiments. The majority of the students explained that they had never been given an opportunity to conduct a preliminary research and to design an independent experiment.

The students stated that the lecturer's involvement in the practicum activity was very minimum. 56.2% of the students stated that the Biochemistry lecturers never gave an explanation of the topics to be practiced, 61.9% of the students stated that the lecturers did not give feedback, and 65.7% of the students stated that they did not have an opportunity to have a discussion. In addition, 66.7% of the students stated that they never discussed the results of the Biochemistry laboratory work in the class.

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The results of the questionnaire analysis distributed to the students were corroborated by the students' written comments and suggestions. The comments from 105 students showed that there were four factors being focused on, namely the laboratory instruments or facilities, laboratory work materials, lecturers' involvement, and the laboratory work implementation. The summary of the students' comments are shown in Table 1.

From the questionnaires distributed to the Biochemistry lecturers, it was described that the Biochemistry course was equipped with laboratory work. In addition, the goal of the laboratory work was clearly stated in the laboratory work manual, the implementation of the laboratory work was integrated with the theories learned in the class; there was a concordance between the laboratory work material and the materials presented in the class, and before the laboratory the goals of every laboratory work activity were explained. Biochemistry lecturer gave meaning to the integration of the theory and practice done by combining the evaluation results of the laboratory work and the scores of assignments, midterm tests and final tests.

Some statements in the questionnaires show that some activities were not done, according to two lecturers. Lecturers did not provide an opportunity for the students to conduct preliminary studies, discuss the preliminary studies being conducted, carry out the experiment according to the laboratory work manual, propose more laboratory work topics to be demonstrated by the laboratory work assistants and lecturers, and the students were not given opportunity to present and discuss the results of the experiments in the class. In addition, efforts were not made to use laboratory work materials which could be found in the surrounding environment, although they had discussed the issues previously. Lecturers did not give feedback to the students' laboratory work reports. The evaluation of the laboratory work reports were entirely conducted by the laboratory assistants. Although every year the laboratory work manual is revised, it has not been designed to develop the students' critical thinking skills. The Biochemistry lecturers suggested to improve the learning and teaching of Biochemistry by extending the duration of the laboratory work, and it was necessary to provide a training session for the lab assistants assigned to help the Biochemistry laboratory work.

TABLE 1. SUMMARY OF STUDENTS' COMMENTS

No.	Suggestions	Percentage (%)
1.	The Laboratory Facilities Must Be Added And Repaired, Especially The Laboratory Glassware And The Laboratory Work Materials.	61
2.	Laboratory Work Materials:	
	A. Laboratory Work Materials Must Be Updated	6
	B. Relevance With The Theories They Learn In The Class	27
3.	Lectures' Involvement In The Implementation Of Laboratory Work, Feedback And Discussion Of The Laboratory Work Results.	35
4.	Implemetation Of Laboratory Work:	
	A. Laboratory Cleanliness	3
	B. Discipline Of The Laboratory Work Assistants	16
	C. Grouping	5
	D. Meaningful Reports	4

The research results being explained above were used as the basis to develop the biochemistry laboratory work. In accordance to the requirements of the chemistry curriculum in the university, Mbajiorgu & Reid [11] show that laboratory work aims should emphasise the role of labwork in making chemistry real as well as developing (or challenging) ideas rather than a focus on practical hands-on skills; labwork should offer opportunities for genuine problem solving. Laboratory work does not necessarily train the students' psychomotor, but it is also expected to develop ideas and processes, and to offer ample opportunities for students to solve problems completely.

Laboratory-based learning consists of four types, namely expository, inquiry, discovery, and problem-based learning. These types of learning are classified based on three descriptors, namely outcomes, approach, and procedures. The three laboratory-based learning descriptors are shown in Table 2. The outcomes of all types of laboratory-based learning can be predetermined or undetermined. The expository, discovery, problem-based learning activities have predetermined outputs. In the expository learning, both students and instructors will know the expected outputs. For the discovery and problem-based activities, only instructors

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know the expected results. Expository and problem-based learning specifically use deductive approach which preconditions the students to use basic principles to understand specific phenomena. The discovery and inquiry learning allow students to use the inductive approach through observation of real examples [12].

TABLE 2. DESCRIPTORS OF THE LABORATORY-BASED LEARNING

No	Style	Descriptors		
		Outcome	Approach	Procedure
1	Expository	Predetermined	Deductive	Given
2	Inquiry	Undetermined	Inductive	Students Generated
3	Discovery	Predetermined	Inductive	Given
4	Problem-Based	Predetermined	Deductive	Students Generated

The implementation of cookbook laboratory experiments using an expository method has some limitations, such as (1) students tend to repeat the observation conducted by the previous batch; (2) students have limited understanding regarding the laboratory work process; (3) students conduct the laboratory work only by using a cookbook method without having an opportunity to make and develop a hypothesis; (4) students are not trained to be responsible for their own groups [13]. Cookbook laboratory experiments do not create a meaningful learning as it is only able to develop lower-level cognitive skill [14,12].

The expository method to implement laboratory work is not always a bad method. The expository method is good to convey basic knowledge, but it is not good to apply and train students' analytical skills [15].

The ability to develop students' critical thinking skills can be evaluated through their laboratory work written reports. The analysis result of 105 students' laboratory work reports highlights some shortcomings, such as:

a. Quotes are not cited clearly.
b. Inconsistency between quoted texts and references
c. The discussion section focuses more on explaining working methods than on the laboratory work results
d. The written language is hard to understand.
e. The students are unable to connect the results, theories cited in the theoretical foundation and the concepts learned in the class.
f. Students are not able to defend the laboratory work results so that in the discussion, it is common to see expressions such "due to student's errors."
g. The sentences in the conclusion section are too long.

The students' Biochemistry laboratory work reports have not been used as the materials for an integrated evaluation of the theories. The laboratory work evaluation is fully given by the laboratory work assistants, while the students' laboratory work reports end at the evaluation stage. An oral report and information sharing with other students as a useful feedback of the investigation process have not been done.

Reid & Shah [8] identify some problems which impede laboratory experiments in the university such as (1) the concept of laboratory experiments has not been implemented properly in the higher learning institution, (2) the cost and time are not worth students' learning experience, and (3) the overlapping of the skills students are expected to master. The tendency to use the expository method also dominates the implementation of laboratory work so that it does not develop students' critical thinking skills. This triggers the development of other methods to be able to produce high-quality laboratory work in the university.

Bartholomew et al. [16] compare the expository laboratory experiments and simulation. The research results illustrate that a simulation approach gives the same performance as the expository method even though the students' ability to use laboratory simulation exceeds those who use expository laboratory work. The laboratory simulation approach brings more advantages to the students in that students are able to control time, location, and speed of their interaction compared to the laboratory work using expository instruction.

Other research attempts to replace the expository method with another method in the laboratory experiments. Vianna et al. [17] use a mini project which results in the increase of students' self confidence. It is reported that the inquiry laboratory approach has advantages such as in developing students' understanding on materials, and applying their knowledge in new situations; improving ability in the knowledge construction, reasoning, communication, explanation, and the increase of motivation among the students [18,19]. The excellence of inquiry-based laboratory instruction shows that the laboratory work patterns in the university should reduce the use of expository method in the implementation of laboratory work. The inquiry method in the Biochemistry course is expected to facilitate students to observe phenomena macroscopically, so that it would be easier to connect microscopic and symbolic aspects. In addition, inquiry-based laboratory instruction can develop dynamically according to the phenomena being observed by the students in their daily life. This is different from the current laboratory work which is implemented merely to copy the existing laboratory work manual and which has not been reconstructed.

In addition to the inquiry method, the use of *Problem Based Learning* (PBL) in the chemistry laboratory work can be an alternative to increase the quality of laboratory work. Liceaga et al. [20] found that 80% of the students treated with modified Problem-based learning approach gained enough background knowledge to understand and solve the problems, 70% of the students show that the use of PBL approach can reinforce the course materials during the course and laboratory work, 50% of the students respond that PBL can help them develop new ways of reasoning the learning materials and 65% of the students respond that teaching using PBL will train students' critical thinking skills. From the survey, 56% of the total respondents prefer to participate in a modified PBL compared to the expository method.

The concept of mini laboratory emphasizes on the fact that laboratory is not limited to a building containing chemical equipments and samples, but has a wider meaning. Laboratory work can be done outside the laboratory and students can be required to design their own laboratory work. The problem being investigated in the laboratory work can adopt problems in the society, such as malnutrition or enzyme utilization to create a simple product.

The result of the questionnaire analysis being described above provides an opportunity for development in Mataram University. The development of mini laboratory model attempts to seek integration between laboratory work and face-to-face interaction in the Biochemistry course. The integration is related to the implementation process of the laboratory experiments all the way through the evaluation process, not by combining the evaluation results of the laboratory work and the assignment scores, midterm tests and final tests. The learning model shows that laboratory work and face-to-face interaction are a continuous learning cycle to attain correspondence between theories and practice. Evaluation is not merely assessed through laboratory work combined with midterm and final tests. Evaluation is done through the assessment of the students' laboratory work reports by giving them a chance to present the results of the laboratory work and an opportunity for the lecturers to discuss the results of the laboratory work.

Efforts to develop a mini laboratory model are expected to facilitate students to develop high critical thinking skill and scientific attitude. In addition, a KKNI (Indonesian National Qualifications Framework)-based curriculum is about to be applied in the university for undergraduate students qualifications which cover attitude, values, work skills, mastery of concepts in specific and general fields of knowledge, and responsibility. The qualifications are closely related to the thinking skills which do not only cover a critical thinking process but also involve the development of attitude [21]. The laboratory work activities are able to develop students' critical thinking skill and attitude [22].

Mini laboratory is expected to solve the Biochemistry laboratory work problems in Mataram University as characterized by (1) the integration of the learning process in the class and that cookbook laboratory experiments which only copy previous laboratory work procedures can be minimized, (2) unlimited to building, chemical equipments and samples, but on the reuse of waste and cases existing in the environment so that laboratory work manual will be more dynamic and relevant to current situations, 3) students are given opportunity to design their own investigation, and 4) students' written reports are used as the basis of evaluation which allows students to write a good and systematic Biochemistry laboratory work report and to present the results of the laboratory work in the class.

IV. CONCLUSION

The findings from the analysis of the students' and Biochemistry lecturers' questionnaires show that the integration of Biochemistry laboratory work and the theoretical lectures in the class is not optimum yet. This is shown by the fact that students were not given opportunities to conduct a preliminary research, lecturers' involvement in the process of laboratory work was not optimum and the lecturers did not give feedback on the results of laboratory work through a presentation. Students' laboratory work reports have not become an integral part of the classroom learning process. The results of the analysis of the students' Biochemistry laboratory work show that the students have not developed their critical thinking skill. This finding opens an opportunity for the development of mini laboratory model which is integrated, unlimited to space, dynamic, and which allows students to present the results of the laboratory work in a class presentation.

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