

EFFECTIVENESS OF LABORATORY PRACTICE USING DISTANCE LEARNING TO ACHIEVE STUDENT'S COMPETENCE IN GENETICS COURSE

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Abstract

Genetics is one of the field in Biology that usually requires laboratory practice, or practicum, to increase student's understanding in the course. Therefore, it is of importance for every open university, including Indonesian Open University (*Universitas Terbuka* or UT), to have a good strategy in conducting laboratory practice in genetics course. The genetic practicum in UT is conducted in collaboration with partner universities (PU) in its regional office. The aim of this study is to determine the effectiveness of laboratory practice performed in PU in achieving student's competence in genetics course. Observation and sampling in this study were performed in four PU that has the most registered student. There are two types of score in this study: lab work score and student competency score. Lab work score measures whether the practicum procedure performed in PU is conducted according to UT's guideline. Student competency score measures student's understanding in the lab work. Effectiveness score was measured using effectiveness ratio test, followed by Kruskal-Wallis test to obtain the significance of the difference between each PU. This study shows that PU with minimum score of 28 is categorized as effective in achieving the minimum score of student's competence. Therefore, we recommend the practice of genetic lab work conducted by the aforementioned PU to be implemented in UT.

Keywords: Effectiveness, practicum, distance education

1. INTRODUCTION

Biology is one of the sciences that during the learning process of the students require a hands-on experience. Based on Yu, Brown, and Billet, studying biological sciences is a combination between understanding, conceptual, and hands-on experiences¹. Subiantoro, 2009 also stated that learning process in natural sciences or life sciences such as in Biology should emphasizes in giving hands-on experiences to develop competences to explore and understanding how the universe works scientifically so that it can enhance student's understanding to real has a grasp on how the nature works². Therefore, it is of importance that practicum is highly recommended for student's learning processes.

Indonesia Open University is one of the universities that offers Biological Sciences Study Program, which is coordinated or under the supervision of Faculty of Mathematics and Natural Sciences (in Indonesian: Fakultas Matematika dan Ilmu Pengetahuan Alam, or also known as FMIPA). Although as an institution UT has a method in performing distance education (in Indonesia: pembelajaran jarak jauh, or also known as PJJ), but several learning activities is still performed by face-to-face methods in the class, just like a regular learning process in non-open university or conventional type of education³. One of the activity in practicum in Biology Study Program is performed by conducting partnership with laboratory in different study program from other universities or partner universities. This practicum activity is an obligation for

student's as part of a course, with the requirements that the Biology student should already took the theory classes or theory classes taken in the same time with practicum courses.

Implementation of practicum with distance learning method like in UT is not easy at all/can provide a challenging task. Several challenges may include the difficulty by the student to attend the practicum since most of the students is an adult and already has a profession or working. In addition, not all partner universities would like to provide facility for UT's student practicum since the number of students are very low. Moreover, the facility provided by the partner universities may lack some facility or lack something important in practicum⁴. Besides that, various characteristics from UT student can also be obstacle. UT student has various background educational, social, economical, and professional work; thus, practicum must be designed in a particular way to solve these differences in these aspects (more importantly: the differences in student competencies). It is known that planning, organizing, implementing, monitoring, and evaluating can have an impact on the result of student learning process⁵. Therefore, the execution or implementation of practicum in UT must be established or made with the purpose or aim and management that is appropriate or in a correct way, so that it will be in accordance with the expected competency.

At UT, evaluation of the achievement of practicum competencies is not performed through written test, but through the score obtained in the lab work report that is submitted by the students in each lab in partner universities. This allows the possibility to have differences in standard and obtainment of competencies in each student based on the place of the practicum (at which partner universities does the practicum performed). Research on practicum evaluation in the Department of Biology in UT has been previously carried out, in which it is specifically studied about observing the accomplishment of competency based on the suitability or accordance with the practicum unit with the UT's required text-book (Buku Materi Pokok atau BMP UT), but has not yet analyzing the extent of competency achieved by students based on one of Biology's field⁶. Based on these condition, it is of importance to understand the effectivity of learning methods conducted in partner universities towards the achievement of practicum competence, thus it will be possible for us to find the best practices for practicum for UT's biology student.

Since not all practicum course are performed, thus the focus of this study is on the genetics course. The consideration is that genetics is an obligatory and basic course, and also as a requirement for joining or registration of final project (in Indonesian: Tugas Akhir Program, or abbreviated as TAP). Based on 2017.2 student registraion (the second intake of students in 2017), it is known that there were 53 students who registered in Genetic's Practicum with the highest distribution of learning place is in UT's Regional Office Yogyakarta (13 students), Pangkal Pinang (21 students), Surabaya (11 students), and Bogor, Jakarta, Serang, Bandar Lampung (4 students). In this study, not only that we are aiming to understand the effectiveness of laboratory practice on each partner universities, but also to understand the differences in competency achievements among each partner universities.

2. METHODS

This study was conducted on the students of Biology Department, Faculty of Mathematics and Natural Sciences (FMNS), Indonesia Open University who registered in Genetic Practicum's Course for the 2017.2 curriculum period, in which the total number of students are 53. Laboratory practice is a concept that is an active learning process that requires students to observe, perform experiment, or test a theory or a concept taught in Genetics Course. Specifically, this laboratory practice is performed in laboratory (as expected, based on the definition). As a Higher Education with Distence Learning Method, the laboratory practice in UT, in particular in the Department of Biology FMNS, is still carried out in collaboration with

laboratories in other universities, or with the so-called partner universities that is located with the regional office that provides the Genetic Practicum's Course. Therefore, students registered in different regional office will conduct the practicum with different partner university. The partner universities chosen for this study consist of four universities, namely PU A, B, C, and D. (The use of the initial is for confidential discretion. For more information regarding the identity of the universities, please contact the authors). The four partner universities were chosen since they have the greatest number of students registered in the course compared to other partner universities.

Data collected in this study include the sociodemographic characteristic of the student conducted or registered in the practicum (data such as: Name and Student Identity (ID), age, gender, formal educational background, employment, and regional office in which the students are registered). The data is obtained based on the observation of practicum activity in each of the partner universities, and the data is collected using observation sheet. Observation sheets are developed based on reference to the standard operational procedure of laboratory practice which includes preparation steps (7 observation components), implementation steps (5 observation components), and follow-up action (3 observation components). The assessment is given by scoring on each step of the implementation using the following rule: two if the steps are performed accordingly and based on the order, one if the steps are done incorrectly, and 0 if the steps are not performed. The scoring rule are expected to be able to anticipate the differences in the scoring standards on each observer, given the implementation of practicum assessment in each partner universities is carried out by different observer. This observation is used as a reference for assessing the suitability between the practicum implemented at partner universities with the standard operational procedure of laboratory practice.

For the data of student competence on practicum, it was obtained from filling out the questionnaires by students in which testing the concept on genetic practicum after they conducted the practicum. The questionnaire was developed according to the genetic practicum teaching material in Indonesia Open University. The results of the student competency assessment are categorized into two groups, with the value threshold of 75: "good" category if the student obtain score of more than 75 (or at least 75), whereas if student receive the score of less than 76 means that they did not perform well. The observation sheets for practicum implementation and questionnaire related to mastering the concept of genetic practicum was reviewed by the lab practice coordinator and lecturer of the genetics course assess the validity of the content of both instruments (questionnaire and observation sheets).

All analysis was performed using Stata SE 12.0 (College Station, TX). Categorical data of sociodemographic characteristics were obtained using frequency distribution. The assessment of the effectiveness level using the effectiveness ratio test, which is analyzing comparison between the number of students who get at least B (in which is at least get 76) with the students who got less than B. If the number of the students who obtained the score of at least B ($\geq B$) is more than the number of students who get less than B ($< B$), then the practicum in the partner universities can be categorized as effective, and vice versa. Further analysis was performed by testing the normality of the data using Shapiro-Wilk test. Kruskal Wallis test was conducted to determine the significance of the differences in competency scores between partner universities.

Before the data collection was carried out, permission from the student and the partner universities that were the subject of this study were already obtained. The confidentiality of the data and identity of the practicum participants and partner universities involved was fulfilled by the use of anonymous.

3. RESULTS AND DISCUSSION

Of the total of 53 students registered in genetics practicum, nearly 70% of them (37 students) is categorized as respondents. Based on the sociodemographic characteristics of students presented in Table 1 below, it is known that most of the practicum participants were less than 35 years old, female, and has employed. Based on educational background, 59% of the participant (student who took the practicum) has diploma 3, with most of the participants are in partner university D.

Table 1. Sociodemographic characteristics of Laboratory Practice Students in Genetics Course

No	Sociodemographic Characteristics	n (%)
1	Age (years)	
	< 35	29 (78%)
	35-45	1 (3%)
	>45	7 (19%)
2	Gender	
	Male	11 (30%)
	Female	26 (70%)
3	Educational Background	
	Senior High School	14 (38%)
	Diploma 2	1 (3%)
	Diploma 3	22 (59%)
4	Employment	
	Employed	36 (97%)
	Unemployed	1 (3%)
5	UT's Regional Office	
	Bandung	1 (3%)
	Bogor	2 (5%)
	Jakarta	1 (3%)
	Pangkalpinang	18 (49%)
	Semarang	1 (3%)
	Surabaya	6 (16%)
Yogyakarta	8 (22%)	
6	Partner Universities (PU)	
	PU A	3 (8%)
	PU B	9 (24%)
	PU C	7 (19%)
	PU D	18 (49%)

The scoring of the practicum activity of the partner university performance can be seen from the total score obtained from the observation of the practicum activity. As seen in Table 2, partner university D has the lowest average score compared to other partner universities. According to such scoring, practicum implementation on partner university D can be categorized as lacking in preparation, implementation, and the follow-up action compared to other partner universities. Improper practicum activity can affect the achievement of student competence. Previous experimental study showed that after student undergo the training of "Best Practice Skills Lab", the student competency scores increased significantly ⁷. Further

study of the relationship between PU's weight of score on the achievement of student competencies in this study can be seen in Table 3.

Table 2. Laboratory Practice Observation Results of Partner Universities

Laboratory Practice Procedure	Weight of Score of Partner Universities			
	A	B	C	D
Preparation Step of Laboratory Practice				
1. The instructor explains purpose of laboratory practice	0	2	2	2
2. Preparing the essentials materials and equipments	2	2	2	2
3. Preparing laboratory practice site	2	2	2	2
4. Considering number of students, available equipments, and laboratory capacity.	2	1	2	1
5. Preparing safety factors for laboratory practice	2	1	0	1
6. Preparing discipline rules during practice	2	2	2	1
7. Making steps and instructions for laboratory practice	2	2	2	1
Implementation Step of Laboratory Practice				
8. Students-instructor discussion about laboratory preparation.	2	2	2	2
9. Instructor observes the laboratory practice process both whole or small group	2	2	2	1
10. Providing assistance and encouragement for students difficulties during practice	2	2	2	1
11. Laboratory practice carried out in group, each group consists of 8-15 students.	1	2	2	1
12. Implementing the laboratory practice component according to practicum teaching materials	2	2	2	1
Follow Up Action				
13. Each students make laboratory practice reports	2	2	2	1
14. Discussing the problems that occur during practice	2	2	2	1
15. Ensuring equipments cleanliness and safe keeping	2	2	2	1
Total Score	27	28	28	19

*Median (IQR)= 27 (19-28); Mean: 25.5

Table 3. Effectiveness of student's laboratory practice competence between partner universities

Partner Universities	Distribusi Frekuensi		Effectiveness Ratio Test		Between PU	p (Post Hoc Test)
	Good (Score ≥ 76)	Poor (Score < 76)	$\geq B : < B$	Effectiveness		
A (n=3)	2 (67%)	1 (33%)	2:1	Effective	A and B/C	0.6403
B (n=9)	8 (89%)	1 (11%)	8:1	Effective	B/C and D	0.005
C (n=7)	7 (100%)	0 (0%)	7:0	Effective	D and A	0.2271
D (n=18)	8 (44%)	10 (56%)	8:10	Ineffective		

* Kruskal-Wallis Test: p value = 0,02

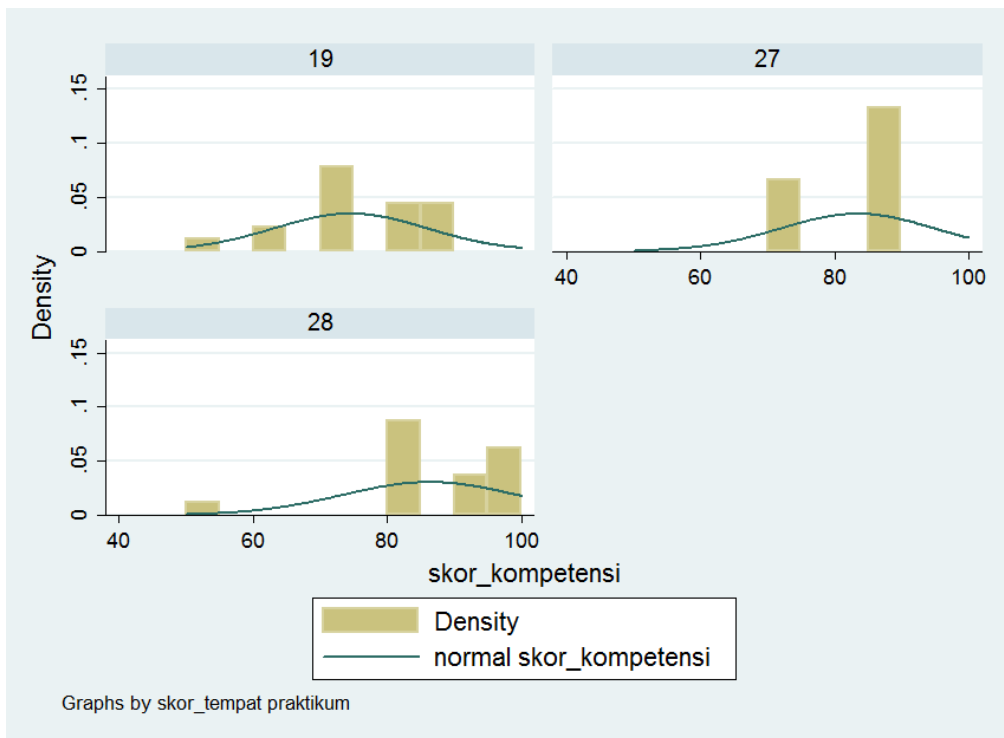


Figure 1. Histogram of Data Distribution in Partner Universities

Teaching of practicum activity in the distance learning remains challenging until to date. Practicum activity on each of the PUs is expected to accomplish the minimum competency standards that must be accomplish by students. Student competency scoring results in each PUs are presented as a frequency distribution data. Therefore, students are classified as having a good competence if achieve a minimum score of 76, whereas student who achieve less than 76 is categorized as not achieving the minimum competency (Table 3). PU C has all students that is classified as achieving a good competency, whereas in PU D, more than half of the students (56%) did not achieve a good competency. Based on the effectiveness ratio test, the laboratory practice of genetics practicum course in PU A, B, and C is effective in achieving student competency, in contrast to PU D.

Further analysis was performed to determine the significance of differences in student competency scores between PU. In this significance test, the data are classified into three groups based on the weight of score result of the practicum place (Table 2), in which the PU A has the score of 27, PU B and C has 28, and PU D has 19. Based on the Shapiro Wilk test, the data obtained in this study is not normally distributed. Based on the histogram (Figure 1), it is shown that the form of data distribution in the three groups is not the same, therefore the difference test with Kruskal-Wallis can only be used to measure the difference in average score or mean only. Based on the value of chi-squared test with DF 2, the kruskall wallis score is $p = 0.02$ ($p < 0.05$), which means there is a significant difference in the average score of practicum competency in PUs. Further analysis using post hoc test showed that the mean score differ significantly between PU D (which has the score of 19) and PU B and C (which have the score of 28) (p -value < 0.05). The findings of this study indicate that PU of UT can effectively achieve good laboratory practice competency score for students if they are able to conduct the practicum based on the procedure with a minimum weight of score of 28. On the other hand, PU D (with a weight of score of 19) was categorized as ineffective in achieving minimum score of student laboratory practice competencies.

Based on the results of the Kruskal-Wallis and Post Hoc test analysis, the practicum activity at PU D needs attention from UT. Moreover, this is mainly aimed at the procedure of

laboratory practice that categorized as important but was conducted poorly. One of the aspects that need to be considered is the comparison between the number of students with the number of available equipment in the laboratory. Ideally, every student has their own equipment in the lab, thus giving them the opportunity to perform experiment independently⁸. Another study also showed that the availability of lab facility is important for student achievement during their study⁹. Considering that the number of students having practice at PU D is relatively high compared to other PU, thus the practicum activity needs to consider the availability of equipments. This aspect also relates to the consideration of distributing the number of students in each group. It is worth noting that the practicum at PU D was divided into two groups (with each group has 9 students). This classification of student group is in accordance with the regulation in UT, which is stated that each practicum group consist of at least 5-10 students¹⁰. However, with the limited number of laboratory equipments, the group classification in PU D is relatively large, thus resulting in minimal involvement of students in each practicum. One of the solutions that can be offered to PU D is by dividing into smaller groups, thus resulting in longer practicum activity¹¹.

Another important aspect that needs to be considered at PU D is the role of practicum instructors in carrying out their duties. Based on the observation during the study, the instructor has explained the outline of the practicum. However, it is still not optimal since the explanations was given to large number of students, resulting in not all students gain understanding of the practicum. Moreover, the condition was exacerbated by instructors who did not encourage active participation of students and there was also very minimum time to discuss the content and problems occurred during practicum. Study showed that student participation is influenced by the characteristics of learning instructional¹², thus also affecting student participation during laboratory practice. There is also one component practicum that is not carried out in PU D since there was no laboratory equipment available, which is the experiment using fruit fly. To overcome this problem, it is necessary to increase the socialisation of practicum at PU, especially emphasizing the role of instructor as a practicum guide and the implementation of practicum according to the main learning materials. These activities can be carried out during monitoring of the practicum, and afterwards the evaluation of such activities can be conducted later.

Several other procedures were also carried out improperly at PU D, such as lack of discipline rules during practicum, implementation of cleanliness and safe keeping of the laboratory equipment that have been used, and safety aspects during practicum. In the standard procedure of practicum, these aspects are classified as complementary procedures, and therefore the implementation will not directly affecting the achievement of student competencies.

Another important factor during practicum activity is the experience of the practicum instructor. A study showed that experience of the instructor has a significant positive correlation to the student skills¹³. This findings are also supported by another study, in which it was found that the knowledge of the content will increase the professionalism of the instructor and increase the student learning process¹⁴. However, we did not collect the data of the instructor's experience in our study.

In addition to being determined by the practicum organizer at PU, the achievement of the student's practicum competency is also determined by the cognitive ability of the students themselves. This aspect refers to Novak's Theory that cognitive, affective, and psychomotor domains complementing each other in order to achieve optimal learning process. This is supported by a finding that for meaningful learning process during practicum at undergraduate level, students must actively integrate cognitive and affective domains in their laboratory practices¹⁵. Another finding also showed that skill and knowledge have a fairly high correlation¹⁶. Therefore, it is of importance to have further study on the cognitive ability of the student to

determine the solution for the ineffectiveness of practicum implementation on the achievement of student competencies at PU D.

4. CONCLUSION

Most students who took the genetics practicum are recruited as respondents. Most students did the practicum at the Partner University D. They are mostly aged 35 years old or less, having job, and mostly female. This study showed that practicum at University D was not effective toward minimum score achievement of genetics practicum by the students. The different score of practicum implementation between University D and University B and C resulted in different mean score of student's competence significantly.

In order to reduce a possibility of students achieve different level of competence, there should be a standard of practicum implementation in partner universities. An indicator that can be used as a standard is observation sheet with a minimum total score of 28 and maximum score of 2 in each practicum step. Those score limits are effective in achieving student's minimal competence. This standard may reduce a possibility of students achieve different level of competence across different partner universities in different areas.

There should be improvement of practicum quality so that the practicum actually compatible to the standard and effective to achieve students competence. Some suggested interventions include improvements in socialization, monitoring, and evaluation by the head office in every steps of practicum. Generally, these finding can be used as a base for developing guidance of practicum of biology at every partner university.

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