



## The Development of Plant Physiology Practicum Guidelines Based on Learning by Research for Biology Education Students

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### Abstract

Universities are currently focusing on developing two aspects, namely being a learning college and a research college. Scientific attitudes, scientific processes, and scientific products are special characteristics of the research learning process. The three components of research learning are developed by educators, both teachers and lecturers, maximally in practicum activities in the laboratory. Therefore, as a first step in student learning, lecturers should be able to innovate and be creative in utilizing existing resources for example by the preparation and implementation practicum based on learning by research model. The purpose of this study is to produce a practicum guideline of Plant Physiology based on Learning by Research that is valid, and practical for use in the Biological Education Program of Universitas Muhammadiyah Makassar. This research is Research and Development (R&D) with using plomp development model. From the results of the research that has been done shows that the practicum guide of Plant Physiology based on Learning by Research that has been developed meets valid and practical criteria. The validation result of the guide is obtained the average value of the Content Validation Coefficient of 0.88 or has high relevance. While the practicality test is in the category of 'overall implemented' with a value of 3.56.

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## **INTRODUCTION**

The learning process in university aim to help improving students' skills to enter the job market very well, having skills that are in accordance with the needs in the field. It even has general skills that can be accepted by government and private agencies. So that learning colleges position the implementation of the dharma of learning prioritized over the dharma of research and community service. Meanwhile, research universities strengthen their focus on research programs to find new theories and technologies, and contribute to industry and contribute greatly to the development of the nation (Rosyada, 2016).

The chieives of the Universitas Muhammadiyah Makassar through the LP2AI institution provides workshops for lecturers in developing and implementing learning based on reaseacrh to supports the institution becoming research university. Biology Education Study Program is one of the Education Study Programs at the Teaching and Educationl Sciences Faculty that should be able to respond (answer) these demands. The response was intended as an effort to realize the University's vision, but more important, to increase the Biology Education Study Program as the basis for the development of knowledge. In accordance with Permenristek Dikti No.44/2015 concerning Graduate Learning Outcomes regarding Attitudes, General Skills and Special Skills of graduates as the fulfillment of the learning outcomes of the study program. Biology lecturer resources who are open to the development and innovation are the fundamental assets for making changes in the study program towards progress.

Lecturers are required to be more creative, and innovative, students are considered as adults, they are not as objects of learning but a subject of learning, so the learning process must be creative, fun, and motivate students and appreciate their every opinion. The results of holy research in Hafsah (2015) stated that students' difficulties and failures are caused by internal and external factors including students, facilities, curriculum, learning resources and the ability of lecturers in teaching students.

The scientific attitude, scientific process, and scientific product are the special characteristics of the research learning process. The three components of research learning are developed by educators, either teachers or lecturers maximally in practicum activities in the laboratory (Wijaya, 2012). Through practicum activities, students can prove the theory received during lectures or discover new facts that have not been patented by other inventors. Students will get direct experience through practicum activities and gain knowledge when proving theories and concepts (Ali, 2017). The implementation of practicum activities so far is still in the form of simple theory testing in the laboratory, so the existence of a Learning by Research-based Plant Physiology practicum guide is very much needed by students to improve scientific skills and attitudes by making mini research.

Research-Based Learning is a learning model that makes problems in research groups as the main language in lectures. A lecturer in lectures not only presents old concepts, concepts that are not phenomenal let alone not contextual in accordance with the development of the times or science itself, but a lecturer must present studies in accordance with the findings in accordance with the latest scientific developments in the study group (Dafik, 2015). Research-based learning has staged that a. Formulating a general question; b. Overview of research-literature; c. Defining the question; d. Planning research activities, clarifying methods/ methodologies; e. Undertaking investigation, analyzing data; f. Interpretation and consideration of results; g. Report and presentation of results (Hidayah, 2018).

If a strategy is integrated with research in learning, among others, it can enrich teaching materials with the results of lecturer research, Using the latest research findings and tracking the history of the latest developments, Enriching learning activities with contemporary research issues, Teaching research methodology materials in the learning process, Enriching the learning process with research activities on a small scale, Enriching the learning process with research activities on a small scale, Enriching the learning process by encouraging learners to feel part of the research culture in the faculty / department, and Enriching the learning process with the values that must be possessed by researchers (Resbiantoro, 2018).

Students are also trained in carrying out activities systematically and scientific methods when carrying out work procedures in the practicum guide. Therefore, as a first step in student learning, lecturers must be able to innovate and be creative in utilizing existing resources, for example by compiling and implementing Learning by Research-based practicum in learning. Practicum implementation will be well

managed and regular if you have a practicum guideline / guide (Prasetyo, 2016). Practicum activities are experiments displayed by educators in the form of demonstrations, cooperative demonstrations by a group of students as well as experiments and observations by students. Such activities can take place in the laboratory or elsewhere. Thus, the practicum guide can be interpreted as a guide or guide to conduct an activity or experiment to test the truth of the theory obtained from the results of learning. Practicum guide is absolutely required by every institution that has laboratory facilities in order for practicum activities to take place in an orderly manner, where practicum guides can be obtained by adopting practicum guides from existing package books or compiling their own simple practicum that is easier to understand (Susanti, J., et al., 2018).

Guide or practicum module as part of teaching materials that are an important component in learning help learners achieve learning goals (Asih, et al., 2018). Through practicum activities, students are directly faced with real symptoms related to the concept of lessons, both natural conditions and conditions manipulated through experimentation (Nengsi, S., 2016). With the development of learning through practicum, students are expected to more easily understand and analyze the concept of learning given. This research aims to produce a practicum guideline of Plant Physiology based on Learning by Research that is valid and practice.

## RESEARCH METHOD

The type of research is research and development (Research and Development) and as research subjects are students of the Biology Education Study Program FKIP Muhammadiyah University of Makassar. The research product to be developed is a Learning by Research-based Plant Physiology practicum guide. This study uses Plomp's (2013) research and development model, consisting of 5 stages, namely: 1) Preliminary Investigation phase, 2) Design phase, 3) Realization / Construction phase, 4) Phase of test, evaluation, and revision, 5) Phase of implementation (Plomp in Rochmad, 2012).

**Preliminary Inverstigation Phase:** An investigative session was carried out in this study to determine the basis of the problems encountered to develop a practicum guideline. In the investigation phase, analysis of practicum topics, student analysis and analysis of facilities and infrastructure is carried out by collecting and analyzing supporting information to plan further activities. From the three analyzes, it can be described as follows. a) Practicum topic analysis; Analysis of practicum topics is carried out to select and determine, as well as systematically arrange topics or practicum units according to the need to be practiced. The topic selection was carried out by considering the suitability of the topic / practicum unit with the composition of the teaching material in the Semester Program Plan (RPS) of the Biology Education study program, FKIP Universitas Muhammadiyah Makassar. Then, the topic / practicum unit will be selected and arranged systematically in the guide which is developed to relate to one another to support the implementation of learning in the form of delivering theory and practice of courses. b) Student analysis; In the process of student analysis, where this analysis examines the characteristics of Biology Education Study Program students according to the design and manufacture of practicum guides. c) Analysis of facilities and infrastructure; This analysis is carried out to see and examine the availability of practical tools and materials that support the implementation of procedures / work methods for each topic / unit in the practicum guide. **Design Phase:** In the design phase, a practicum guide was designed which aims to obtain a prototype of Learning by Research-based Plant Physiology learning products. In addition, the necessary research instruments were made in the form of validation instruments and practicality test instruments when using the practicum guide.

**Realization/ Construction Phase:** Furthermore, the Practicum Guide that has been made in the design phase is referred to as Prototype I. **Test, Evaluation, and Revision Phase:** In the test phase, evaluation and revision are carried out in two stages, is: a) The stages of validation for practicum guides; Prototype I as a product in the realization phase was discussed in the research team. Then it was validated by a team of validators who had been determined, namely two internal lecturers of the Biology Education Study Program. Based on the results of the validation by the validator team, if there are still improvements that require revision, the research team will rearrange the prototype I practicum guide into Prototype II

after being revised. Furthermore, prototype II, which has been concluded to meet the valid criteria can be used for the trial phase of the practicum guide. b) The stages of testing the practicum guide; The trial stage aims to determine the extent to which the Learning by Research-based practicum guide is implemented in Plant Physiology learning. After carrying out the trial phase, it is hoped that you will get suggestions and improvements to the practicum guides that have been prepared so that they become even more complete.

The practicum guide that has been made will be tested on a limited basis for Biology Education students of the Universitas Muhammadiyah Makassar in the fifth semester of the 2020-2021 academic year. The research instruments used in this study were the validation sheet and the practicality observation sheet when carrying out the Plant Physiology practicum. The validation sheet is given to the expert validator team to assess the achievement of the eligibility criteria for the practicum guide developed. The validation team was carried out by two Plant Physiology lecturers. The assessment by a team of experts was then analyzed based on content validation by Gregory in Ruslan (2009), which can be seen in table 1.

**Table 1** Content Validation Analysis

	Val 2	Val	Irrelevant Score (1-2)	Relevant Score (3-4)
1				
	Irrelevant Score (1-2)		A	B
	Relevant Score (3-4)		C	D

$$\text{Content Validation Coefficient} = \frac{D}{A+B+C+D}$$

Note: A: Validators I and II disagree / are relevant (1-2), B: Validator I agrees / is relevant (3-4) and Validator II disagrees / is relevant (1-2), C: Validator I disagree / relevant (1-2) and Validator II agree / relevant (3-4), D: Validators I and II agree / relevant (3-4)

Practical guidance is said to be valid if the validators I and II provide high relevance / agreement (3-4) with the content validation coefficient > 75% (Ruslan 2009). For the practicality criteria of the device, the research team provided an Observation sheet of the practicality of the practicum guide to three lecturers as observers. The mean scores of the three observers were adjusted according to the following categories of implementation.

If  $T \leq 1$ : Not implemented,  $1 < T \leq 2$ : Partially done,  $2 < T \leq 3$ : Mostly done,  $3 < T \leq 4$ : Overall Done

The practicum guide is said to meet the practical criteria if the minimum T value is in the "Mostly Done" category Arif & Maya (2019).

## RESULTS AND DISCUSSION

Research on the development of a Plant Physiology practicum guide based on Learning By Research which was carried out at the Biology Education FKIP Muhammadiyah University of Makassar for semester V students used the research and development model from Plomp (2013). This model consists of 5 phases, namely: (1) the investigation phase (Preliminary Investigation), (2) the design phase (Design), (3) the realization / construction phase (Realization / Construction), (4) the test, evaluation, and revision phase. (test, evaluation, and revision), and (5) the implementation phase. The practicum guide that has been developed has been valid and practical based on the assessment of the validator and observer of implementation. Validated by 2 lecturers and practicality by 3 lecturers.

The stages of the development process of the Plant Physiology practicum guide that have been carried out, along with the results of the analysis obtained, are described as follows.

### Preliminary Investigation

Student Analysis; The results of the student analysis through the process of investigation when the students carried out the Plant Physiology practicum found that the practicum carried out was still merely proving the theories put forward by scientists so that scientific skills had not been fully acquired by students. Analysis of Practicum Topics; The results of the analysis of the practicum topic through the observation process found that the topic or practicum unit in the practicum guide during the last 3 years since the opening of the Biology Education Study Program at Muhammadiyah University of Makassar was

not in accordance with the teaching materials arranged in the Semester Program Plan (RPS). The topic of the Plant Physiology practicum that has been practiced so far is a topic that is considered to be representative. Analysis of Facilities and Infrastructure; The results of observations of facilities and infrastructure found that the Biology Laboratory of the Universitas Muhammadiyah Makassar only had one room. Where one room is used for practicum all subjects that have practice in turns. So, it seems that this room is very narrow because it is filled with tools and materials for all practicum. Irregular practicum tools based on group / class of subjects. Likewise with practicum materials that are out of date, out of stock, and not neatly arranged.

### Design

In this design phase, the researcher has designed a product in the form of a cover guide, and a topic (unit) of the practicum based on the RPS from the Plant Physiology course.

Cover Design; The cover of the Plant Physiology practicum lab guide is designed in such a way that it is very different from the previous cover cover. The cover design was chosen in green with a yellow combination with a leaf motif that is very identical to Biology, especially Plant Physiology, and added some photos of practicum from Biology Education students of Universitas Muhammadiyah Makassar while doing practicum in the laboratory. This practicum guide cover is designed using the Pixellab application. Design of Practicum Topics; Plant Physiology practicum writers who have not yet been developed consist of 6 topics or practicum units, and will be developed into 9 practicum topics. The addition of practicum topics is adjusted to the composition of teaching materials in the Plant Physiology RPS and also adapts to the tools and materials available in the Biology Laboratory. Although the practicum topic is still relatively simple in assembly and implementation, it includes all the teaching materials in Plant Physiology. The practicum topics that will be developed are as follows table 2.

**Table 2** The topic of the development result

Topic	Title
1	Osmosis
2	Plasmolysis
3	Imbibition
4	Water and Land Relations
5	Respiration
6	The Ingenhousz Experiment
7	Sachs Experiment
8	Movement of Plants
9	Seed Germination Hormones

Each Plant Physiology practicum unit is prepared and developed based on Learning by Research with the following main components.

**Table 3** Components of the practicum unit/ topics

No	Item	Deskription
1	Practicum title	describe the activities
2	Basic theory	contains a brief theory that describes the practicum unit.
3	Practicum Purpose	goals to be achieved after carrying out practicum which usually directs students to think at higher levels

4	Practicum Tools and Materials	list of tools and materials used during practicum
5	Procedure	systematic, measurable and sequential steps that will be carried out during the practicum to achieve the goals of the practicum.
6	Observation result	made in a column or table whose shape is adjusted to the data from the practicum results. If the data is in the form of images or graphics, then a column is created. Meanwhile, if the data is in the form of numbers, it is made in table form. Observation results during the practicum are made first in the form of a provisional report by directly filling in the table or column of the observation results. After the new practicum will be made in the form of a complete report
7	Discussion	after carrying out the practicum students answer and discuss the exercises / questions in each practicum unit

**Realization**

In this realization phase, researchers have made all forms of planning and design in the design phase, both in the form of cover design and addition of topics or practical units complete with the elaboration of the components of each practicum topic. Hereinafter referred to as Prototype I. Prototype I is a product that will be validated by the validator team in the test, evaluation and revision phases.

**Test, Evaluation, and Revision**

In the test phase, the validation of the Plant Physiology guide that has been made or what is called Prototype I is carried out by the validation team. The guidance validation activity aims to make the guiding product feasible to be tested on students. The Prototype I validation team consisted of 2 expert lecturers and had or temporarily taught Plant Physiology courses. The validator's assessment of the guidance product by filling out the instrument validation sheet. The results of the evaluation of the 2 validators become suggestions for improvement and a reference in revising Prototype I. After the validation activities, and the author has been revised, the next activity is the testing phase of the guiding product to measure practicality.

**Validity**

Before the guiding product is tried out on students during the Plant Physiology practicum, it must first go through the validation stage. The results of the assessment from the validator by looking at the aspects of the writing format, content and language and writing of the guide as a prototype I product that has been made are presented in table 5.

**Table 5** Validation Results of the Plant Physiology Practicum Guide

N	Aspect	Validator	
		I	II
1	Practicum Guide Format	3,6	3,6
2	Content	2,8	3,5
3	Language and Writing	3,6	3,4

$$\text{Content validity coefficient} = \frac{D}{A+B+C+D} = \frac{15}{2+0+0+15} = \frac{15}{17} = 0,88$$

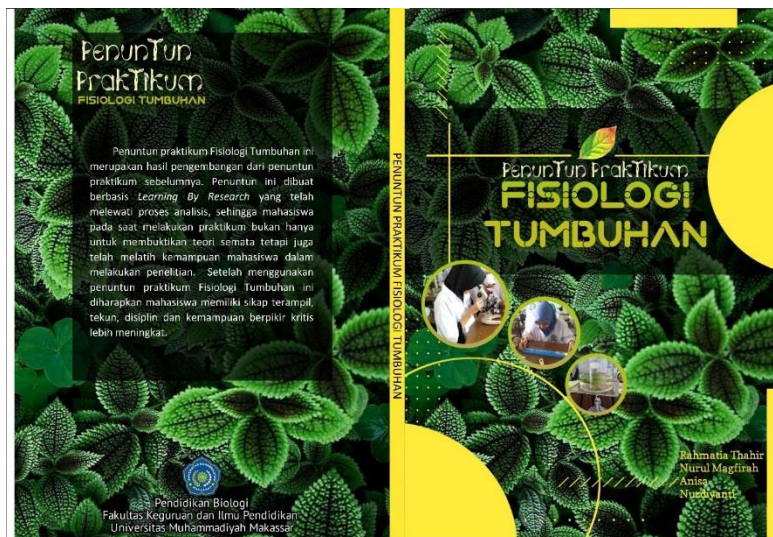
Based on table 5, data from the results of the validation assessment of the Plant Physiology practicum guide obtained a content validation coefficient of V = 0.88 or V = 88%. A guide is said to be valid if the content validation coefficient is > 75%, while V = 88% > 75%. So, it can be interpreted that the practicum guide developed is valid and has high relevance. This means that the structure of practicum guides developed meets the requirements of good learning preparation. The guide already uses writing that is easy to read, is in accordance with the picture with the material or topic that is practiced, and the appearance of images that are interesting for students. The language of practicum guidance developed in

accordance with EYD, namely improved spelling, good language and correct according to the rules of Bahasa Indonesia. The two validators provide a general assessment of the practicum guide that the guide can be used with minor revisions. The suggestions from the two validators can be seen in table 6.

**Table 6** Suggestions from expert validators and their revisions

N	Validator's Advice (before revision)	Follow-up (after revision)
1	Adds the quantity / number of tools and materials that will be used per unit.	Has added the number of tools and the dosage of practicum materials to be used in each unit.
2	Converting some command words into verbs that are in the procedure / way of working.	All statement items in the work procedure use verbs.
3	It is recommended to change the numbering format with symbol (●) to number one (1).	The format of numbering in writing always uses numbers instead of symbols.
4	Add a description of the sections to each test image.	Each experimental image is equipped with a description of the parts of the image.

The suggestions from the two validators were followed up by revising them again. The revised results are then referred to as Prototype II. The guiding product in the form of prototype II will be tested on a limited basis for Biology Education Study Program students, Universitas Muhammadiyah Makassar. The trial aims to measure the practicality of the Plant Physiology practicum guides that have been developed. We can see the implementation of the device after measuring the practicality of the practicum guide developed based on Learning by Research in learning.



**Picture 1** Cover of Practicum Guideline

### Practicality

Practicality trials of the practicum guide as a form of product implementation are used during practicum in the laboratory. Three observers carried out the product practicality observations. Each observer gave an assessment by filling out a questionnaire on the practicality of the Learning by Research-based Plant Physiology practicum guide.

Based on the results of observer observations and providing an assessment of product feasibility summarized in table 5 above, it shows that the Plant Physiology practicum guide based on Learning by Research is in the Overall Implemented assessment category with a T value equal to 3.56. Category  $3 < T \leq 4 =$  Overall accomplished, then  $3 < 3.56 \leq 4 =$  Overall accomplished. This indicates that leaning by Research-based practicum guide can facilitate and assist students in carrying out practicum activities. The results of Syamsu Research (2017) stated that practical practicum guide if easy to use and facilitate students in performing practicum procedures. Practicum guide is intended to help and guide learners to learn and work continuously and directed. With the practicum guide, students will get an overview of the objectives,



benefits, and process of practicum activities that will be carried out. In addition, in this practicum guide can train the scientific skills of students as a scientist. Students will be easier and quicker to understand the concept if accompanied by examples of real objects, so that they learn actively and creatively in developing their scientific abilities.

## CONCLUSION

Based on the research and development results that have been carried out by researchers, it can be concluded that the Plant Physiology Practicum Guide based on Learning by Research using the Plomp development model which consists of 5 phases, namely: (1) investigation, (2) design phase, (3) realization / construction, (4) the test, evaluation, and revision phases, and (5) the implementation phase has met the valid and practical criteria.

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