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*Research Article*

# Development of Problem-Based Learning Student Worksheets to Train Critical Thinking Skills of Students in Biology Education Study Program

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**Abstract.** Critical thinking ability is one of the important competencies that students must possess in biology learning. This research aims to develop Problem-Based Learning (PBL) Student Worksheets to train students' critical thinking skills in Plant Anatomy courses. This research uses the Research and Development method with a simplified 4-D model consisting of three stages: Define, Design, and Develop. The research subjects were second-semester Biology Education Study Program students at Universitas Muhammadiyah Bengkulu. Research instruments included media and material expert validation sheets, as well as student response questionnaires. Validation was conducted by one media expert and one material expert, then tested on 5 students (limited trial) and 22 students (extensive trial). Validation results showed that the student worksheets received a "very valid" category with 86% from media experts and 88% from material experts. Practicality tests showed "very practical" results with 89% in limited trials and 91% in extensive trials. The developed student worksheets contained contextual problem scenarios, systematic PBL stages, and critical discussion questions that encourage students to analyze, evaluate, and conclude based on empirical data. This research concludes that PBL-based student worksheets are feasible to use as learning media to train students' critical thinking skills in Plant Anatomy courses.

**Keywords:** Critical Thinking; Extensive Trial; Plant Anatomy; Problem-Based Learning; Student Worksheets.

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## 1. Introduction

Indonesian higher education continues to strive to improve the quality of graduates who can compete in the global era. One of the important competencies that students must possess is critical thinking ability, which enables them to analyze information, evaluate arguments, and make decisions based on valid scientific evidence.

Problem-Based Learning (PBL) is a learning approach that has proven effective in developing critical thinking abilities. This model emphasizes learning through solving authentic problems that encourage students to actively engage in scientific investigation processes. Student Worksheets as learning media can be designed based on PBL to facilitate the development of students' critical thinking abilities.

This research aims to develop valid and practical PBL-based Student Worksheets to train students' critical thinking skills in Plant Anatomy courses, thereby improving learning quality and student competencies.

## 2. Methods

This research uses the Research and Development (R&D) method with the Four-D (4-D) development model simplified into three stages: Define, Design, and Develop.

The Define stage includes initial analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives. The Design stage encompasses material design, student worksheet creation, media technology specifications, and initial product design. The Develop stage consists of expert validation, revision, and product testing.

The research subjects were second-semester Biology Education Study Program students at Universitas Muhammadiyah Bengkulu. Validation was conducted by one media expert and one material expert from Universitas Muhammadiyah Bengkulu. Testing was conducted in two stages: limited trial with 5 students and extensive trial with 22 students.

Research instruments included validation sheets for media and material experts, as well as student response questionnaires. Data were analyzed using quantitative analysis techniques with percentage formulas to determine the validity and practicality levels of the product.

## *3.* Results and Discussion

### Results of PBL-Based Student Worksheet Development

The developed student worksheets have main components including: attractive cover with plant anatomy images, learning identity, Sub-CPMK and practicum objectives, learning instructions and learning indicators, learning materials with image illustrations, practicum tools and materials, PBL-based activity stages, observation result tables, group report format, critical discussion questions, reflection questions, and critical thinking assessment rubrics.

The PBL stages in the student worksheets were systematically designed including: (1) problem orientation by presenting contextual scenarios related to plant adaptation to environment, (2) learning organization through group formation and task division, (3) independent and group investigation to collect data through microscopic observation, (4) development and presentation of results in group report form, and (5) analysis and evaluation of problem-solving processes through critical discussion and reflection.

### Validity of PBL-Based Student Worksheets

Media expert validation results showed 86% with "very valid" category. Assessed aspects included worksheet appearance (score 76), graphic aspects (score 62), and practical aspects (score 107). The validator provided improvement suggestions including replacing the cover image to better suit plant anatomy material, improving table format, organizing tools and materials using table format, and creating more attractive and creative designs.

### Practicality of PBL-Based Student Worksheets

Limited trial with 5 students resulted in 89% practicality percentage with "very practical" category. Extensive trial with 22 students showed 91% with "very practical"

category. Assessed aspects included ease of use, content effectiveness, usefulness, suitability with learning approach, and technical aspects.

Students gave positive responses to the developed student worksheets. They stated that the worksheets helped them learn independently and collaborate in a structured manner, were more practical due to clear work instructions, and encouraged creativity and critical thinking in problem-solving.

**Discussion**

The developed PBL-based student worksheets proved effective in training students' critical thinking through several mechanisms. First, presentation of contextual problems such as adaptation of plant anatomical structures to environment encouraged students to identify problems, analyze causes, and formulate solutions based on empirical data.

Second, systematic PBL stages facilitated the development of critical thinking indicators such as focus (determining main problems), reason (providing reasons), inference (drawing conclusions), situation (applying knowledge), clarity (giving examples), and overview (checking answer validity).

Third, practicum activities with microscopic observation of plant tissue structures trained students to analyze visual data, compare structures between specimens, and relate structure-function relationships of plant organs. These activities directly honed observation, analysis, and evaluation abilities which are important components of critical thinking.

Fourth, group discussions and reflection in the student worksheets encouraged students to develop scientific argumentation, consider different perspectives, and conduct self-evaluation of the learning process. This aligns with critical thinking characteristics that emphasize the ability to evaluate information objectively and make decisions based on valid evidence.

## *4.* Conclusion

The Problem-Based Learning student worksheets for Plant Anatomy courses that were developed meet the valid and practical criteria for use in learning. Expert validation showed "very valid" category with 86% for media aspects and 88% for material aspects. Practicality tests resulted in "very practical" category with 89% in limited trials and 91% in extensive trials.

The developed student worksheets were effective in training students' critical thinking through contextual problem presentation, systematic PBL stages, investigation-based practicum activities, and reflective discussions. This product can serve as an alternative learning media to improve the quality of biology learning in higher education.

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**Author Contributions**

Conceptualization, WW and SDS; methodology, WW; validation, SDS and I; formal analysis, WW; investigation, WW; resources, SDS; data curation, WW; writing—original draft

preparation, WW; writing—review and editing, SDS and I; visualization, WW; supervision, SDS and I; project administration, WW. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest**

The authors declare no conflicts of interest in the research and writing of this article.

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