Development of Project-Based and *Deep* Learning-Based Student Worksheets in Basic Biology to Improve Students' Critical Thinking Skills

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Abstract. This research addresses the urgent need to enhance college students' critical thinking skills in conventional Basic Biology courses. The Project-Based Learning (PjBL) approach is proven effective in developing higher-order thinking skills. Furthermore, integrating *Deep learning* into biology education can strengthen students' critical thinking by encouraging them to connect biological concepts in depth and apply them in real-world contexts. This study aims to develop a Basic Biology student worksheet that integrates a Project-Based Learning (PjBL) model with a *Deep learning* approach. The goal is to make learning more applicable, meaningful, and reflective, thus equipping students with critical thinking skills. The research is a type of Research and Development (R&D) study, utilizing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), a systematic design framework. The primary data collection instruments were expert validation sheets, student response questionnaires, practicality sheets, and effectiveness tests. The research sample consisted of 40 students enrolled in a Basic Biology course. The results indicate that the Deep-PjBL student worksheet is categorized as Valid, Practical, and Effective. Therefore, it can be used in biology education to enhance students' critical thinking skills.

Keywords: Student Worksheets, *Project Based Learning, Deep learning,* Critical Thinking

1 Introduction

Prospective teacher students must improve their quality by having 21st century skills. This aims to make prospective teacher students competitive and prepare themselves to become professional teacher candidates. It is also hoped that educational institutions in Indonesia will be able to produce graduates who are not only intellectually superior, but also skilled in accordance with the needs of the times and the world of work [1]. One of the skills of the 21st century is critical thinking skills. Critical thinking according to Anugraheni (2020) is a dynamic process, where a person is able to recognize

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differences in information, collect data, analyze the data obtained, then evaluate and draw conclusions from the information/data obtained [2].

Efforts to develop these skills, especially critical thinking, can be honed through various courses facilitated by various learning media. One of the mandatory courses that must be taken by students majoring in Mathematics and Natural Sciences Education (PMIPA) at the University of Riau is Basic Biology. In this course, students are required to be able to think critically in order to be able to relate the concept of biology to the problems of the surrounding environment [2-5]. However, in order for these goals to be achieved optimally, several components are needed such as learning methods, learning media, learning environment, the role of lecturers, and assessments. Based on the results of observations of 40 students, it is known that as many as 51.7% still need learning media in the form of Student Worksheets.

Student Worksheets are sheets containing assignments that must be done by students in the form of questions and student demonstration activities during lectures [6]. Student Worksheets are often used as a medium in practicum learning, but they are generally still procedural, limited to the mechanistic stage and their use is not optimal in encouraging exploration and deep reflection on biological concepts [7]. Student Worksheets can be developed using learning models, one of which is Project Based Learning. Project Based Learning (PjBL) is one of the methods that can be applied as an effort to improve students' critical thinking skills. The implementation of sustainable Project Based Learning measures can increase student activities in learning and direct students to cooperate with each other in completing projects. Project-based Student Worksheets are known to improve students' critical thinking [8]. In line with this, the concept Deep Learning It is also present as an approach that encourages students to build a more meaningful understanding.

Deep learning or deep learning is an approach that encourages learners to understand the material more meaningfully and can relate it to real-life contexts [9]. This approach aims to create a meaningful and immersive yet enjoyable learning experience. This concept emphasizes three main aspects, each of which plays a role in increasing engagement, expanding understanding, and fostering satisfaction in the student learning process, namely mindful learning, Meaningful learning, and joyful learning. Mindful learning emphasizes the importance of awareness and mindfulness in the learning process [10], Meaningful learning that is, associating new information with existing knowledge [11]. While joyful learning emphasizing the importance of creating a fun and motivating learning environment [12]. Not only relevant for students at the primary and secondary levels, the concept Deep Learning is also considered relevant to students. Application Deep Learning It is important for students to be able to face the challenges of the increasingly complex modern world with an emphasis on developing critical thinking skills, creativity, and problem-solving skills [13, 14].

This research aims to develop and test the effectiveness of Project-Based Learning and Deep learning based Student Worksheets on Basic Biology materials to improve students' critical thinking skills.

2 Research Method

This research was carried out at the University of Riau in the period August-November 2025. This type of research is Research and Development (R&D) with the ADDIE (Analyze, Design, Development, Implementation, and Evaluation) development model. The development model used is ADDIE which is one of the systematic design models [15,16]. The flow of MFI development using the ADDIE model is presented in Figure 1 below.

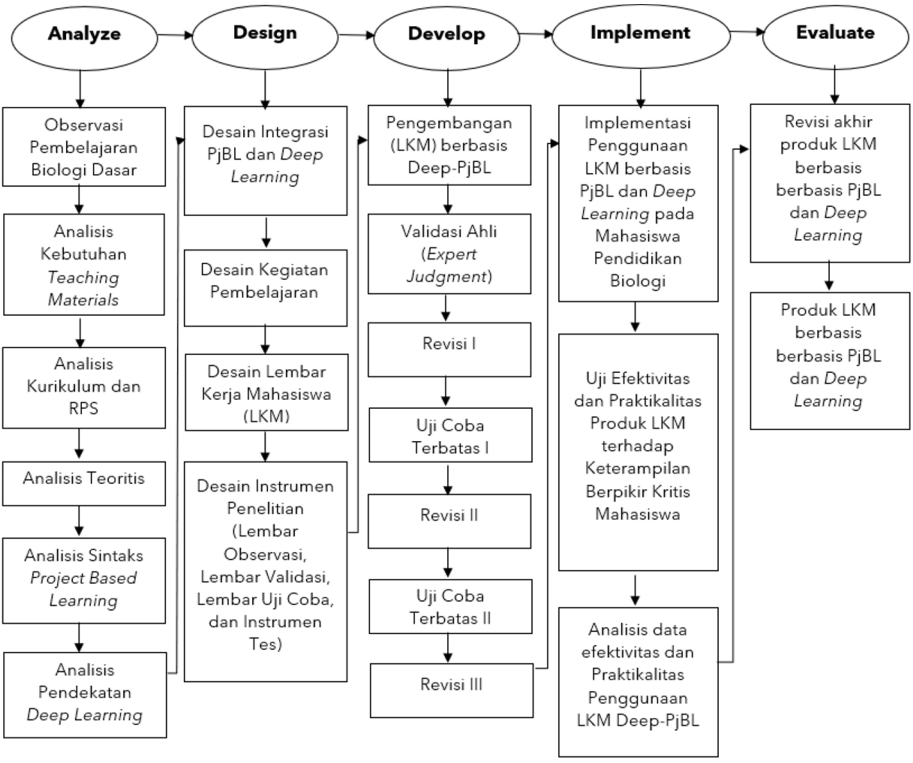


Fig. 1. ADDIE Development Model

The research instruments consisted of validation sheets, response questionnaires, and cognitive tests. The validation sheet for subject matter experts is arranged based on the feasibility aspect of the material, the feasibility aspect of the presentation, the aspect of language feasibility, and the aspect of contextual assessment. Meanwhile, the media expert validation sheet is prepared based on format and graphic aspects, language aspects, and content aspects. Product validation is carried out by 2 validators consisting of media expert lecturers and material expert lecturers. PjBL-based and deep learning Student Worksheets are ready to be used if the average assessment of validators is valid and very valid. The instrument was in the form of a questionnaire with a likert scale of 1-4. The criteria for making decisions on the validation of MFIs can be seen in Table 1. The validation results are calculated using the average score formula, namely:

$$M = \frac{\sum fx}{N} \quad (1)$$

Description :
M = Average score
Fx = Score obtained
N = Number of validation components

Table 1. Validity Categories

Score Interval	Validity Categories
$3.25 \leq x < 4$	Highly Valid
$2.5 \leq x < 3.24$	Valid
$1.75 \leq x < 2.4$	Less Valid
$1 \leq x < 1.74$	Invalid

Modifications (Scott, 2020)

After the validation process, a limited trial was carried out for 10 students who took the Basic Biology course, especially in the Biodiversity material. Furthermore, a limited trial II was carried out on 30 students. At the end of the lesson, students are given a cognitive test to measure their masteryof biodiversity. In addition, students were also given a questionnaire on responses to the use of MFIs in terms of design, pedagogical aspects, and content and language aspects.

3 Result and Discussion

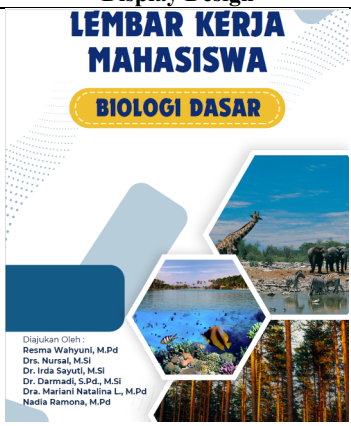
The first stage of the development of PjBL-based Student Worksheets (MFIs) and Deep Learning is the stage of analysis. The analysis stage is the main foundation in the ADDIE model because it functions in determining the focus and content of the product being developed. At this stage, observation of Basic Biology learning needs analysis Teaching Materials, curriculum and RPS analysis, theoretical analysis, and PjBL syntax analysis and approaches Deep Learning. The results of the overall analysis show that the product to be developed must be able to encourage students to think critically while relating the concept of biology to real problems in daily life. Therefore, there is a great need for a learning media that can facilitate prospective teacher students to improve students' critical thinking skills, one of which is by developing PjBL-based MFIs and Deep Learning [17,18].

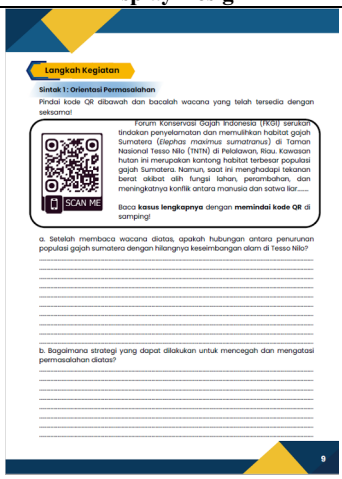
This is also in line with Nurazizah's research et al., (2025), the integration of the PjBL model in deep learning (Deep Learning) is an effective strategy in building a learning culture and is relevant to the educational needs of the 21st century [9]. Various studies have compared the effects of deep learning (deep learning) with conventional learning in improving critical thinking skills. Learning Deep Learning It is known to be able to improve critical thinking skills. Ratnasari's research results et al., (2025) through the deep learning, Critical thinking skills have improved compared to learning with conventional methods [19]. Therefore, the interaction of these two approaches in MFIs

is a strategic step to produce prospective teacher students who are adaptive to the challenges of 21st century education.

The next stage is design. At this stage, MFI design is carried out by paying attention to Aspects of presentation qualifications, language qualification aspects, and contextual evaluation aspects for material experts and format aspects as well as graphics, language aspects, and content aspects for media members. The MFI design can be seen in table 2.

Table 2. Development of PjBL-Deep learning MFIs

MFI Section	Display Design
Cover	 Module cover design design
Contents	 Module content design

MFI Section	Display Design
Syntax of Project Based Learning (PjBL)	 Presentation of *Project Based Learning syntax*
Deep Learning *Integration*	 Deep Learning in MFIs

MFI Section	Display Design
Competency Test	 Final competency test of the module

After completion, the MFI is then validated by experts to assess the suitability of the format. Based on the results of the validation, revisions were carried out and then continued with limited trials until the final revision results were obtained. This stage is carried out so that the resulting MFIs have good quality, according to the needs of students, and are able to achieve the goals that have been set. The results of the validation of MFIs based on PjBL and deep learning can be seen in the following table 3:

Table 3. Results of MFI Validation by Material Experts

Aspects	Average	Categories
Material Feasibility Aspects	3,66	Highly Valid
Aspects of Presentation Eligibility	3,62	Highly Valid
Language Eligibility Aspects	3,14	Valid
Contextual Assessment Aspects	3,55	Highly Valid
Average	3,49	Highly Valid

The table above shows the percentage of material expert validator assessments on the material feasibility aspect of 3.66, the feasibility aspect of presentation 3.62, the language feasibility aspect 3.14, and the contextual assessment aspect of 3.55. So that it produces an average of the results of validation by material experts on MFIs based on PjBL and *deep learning* seen from four aspects, namely 3.49 (Very valid).

Validation by media experts aims to assess the graphics of MFIs based on PjBL and *deep learning.* The results of the validity of media experts can be seen in the following table 4.

Table 4. MFI Validation Results by Media Experts

Aspects	Average	Categories
MFI Size	4,00	Highly Valid
MFI Cover Design	4,00	Highly Valid
Content Design	3,72	Highly Valid
Average	3,90	Highly Valid

Based on table 4 above, it is known that the MFI size aspect has an average of 4.00; the average MFI cover design aspect is 4.00; and the average content design aspect is 3.72. So that obtained the results of the validation of PJBL-based MFI media and Deep Learning of 3.90 (Very Valid). A learning media is said to be feasible if the results of validation assessments from material experts and media experts show a valid or very valid category [20]. Because the validation results by material experts and media experts show very valid results, the MFIs are based on PjBL and Deep Learning designed in accordance with the standards and can be used as a Teaching Materials in the Basic Biology course.

Student Worksheets based on Project Based Learning (PjBL) and deep learning that have gone through the validation stage by material experts and media experts are then continued in trial stages 1 and 2. This trial aims to determine the level of feasibility and applicability of the product that has been developed. The results of the phase 1 trial can be seen in the following table 5:

Table 5. Phase 1 Trial

Aspects	Average	Categories
Planning	3,40	Excellent
Pedagogy	3,50	Excellent
Content and Language	3,40	Excellent
Average	3,43	Excellent

Based on table 5 above, in the phase 1 trial, the average design aspect was 3.40, the pedagogical aspect was 3.50, and the content and language aspect was 3.40, so that an overall average of 3.43 was obtained with the category of Very Good.

Table 6. Phase 2 Trial

Aspects	Average	Categories
Planning	3,62	Excellent
Pedagogy	3,61	Excellent
Content and Language	3,53	Excellent
Average	3,58	Excellent

Furthermore, in the phase 2 trial from table 6 above, the average design aspect was 3.62, the pedagogical aspect was 3.61, and the content and language aspect was 3.53, with an overall average of 3.58 in the Very Good category. There was an increase in the score of the assessment results from the phase 1 trial to the stage 2 trial assessment.

The average phase 1 trial was 3.43 with a very valid category. Meanwhile, the average phase 2 trial is 3.58 with a very valid category.

Thus, the results of phase 1 and 2 trials show that the Project Based Learning *(PjBL) and* deep learning *based Student Worksheets (LKM)* are declared feasible and very good to be used as *teaching materials*. This proves that the product has met the aspects of design, pedagogy, and feasibility of content and language, so that it can be applied in Basic Biology courses to improve student understanding.

4 Conclusion

Based on the results of the study, it can be concluded that MFIs based on PjBL and *deep learning* on biodiversity materials are valid with an average value of 3.69. The average of the phase 1 trial was 3.43 with the very good category. Meanwhile, the average phase 2 trial was 3.58 with a very good category. This shows that the integration of the PjBL model with *a deep learning* approach can train students to think critically. This MFI is expected to be used in lectures to improve students' critical thinking skills. For the next research, it is recommended that the development of other learning media based on PjBL and *deep learning* on other materials.

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