Development of STEM-EDP-Based Student Worksheets to Improve Students' Critical Thinking Skills at SMP Negeri 17 Samarinda

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Abstract: Critical thinking skills are important for students, but not all students possess strong critical thinking abilities. This study aims to develop a STEM-EDP-based Student Worksheet media to improve students' critical thinking skills in the topics of Ecology and Biodiversity. This research uses the ADDIE development model, developed by Robert Reiser and Michael Molenda, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The developed media was validated by experts in content and media, with the media expert validation result being 91% and the content expert validation result being 94%, both categorized as highly valid. Practicality testing was obtained from practicality questionnaires filled out by both teachers and students. The student practicality questionnaire resulted in 90.5%, categorized as very practical, and the teacher practicality test resulted in 90%, also categorized as very practical. The effectiveness of critical thinking skills was assessed through pretest and posttest results, using the N-Gain test, which resulted in a score of 0.7, categorized as high. Therefore, it can be concluded that the use of STEM-EDP-based Student Worksheets to improve students' critical thinking skills is effective and categorized as high.

Keywords: Development; STEM-EDP; Student Worksheets

Introduction

In science education, critical thinking skills are essential for students. Critical thinking is a skill that students must possess so that the accuracy of the information they obtain can be verified (Suriati et al., 2021). Students who possess critical thinking skills will be able to master concepts and solve problems presented in the learning process, as well as apply those concepts to real-life situations (Ariadila et al., 2023). Critical thinking is a systematic and active cognitive process that involves evaluating arguments, assessing facts, evaluating the wealth and relationships of two or more objects, and providing evidence to support or reject a statement (Marudut et al., 2020). The better critical thinking skills are developed in students, the better their ability to solve complex problems with satisfactory results (Jamaluddin et al., 2020).

Critical thinking skills consist of five stages: Providing Simple Explanations (Basic Clarification), Building Basic Skills (Basic Support), Making Inferences (Inference), Further Clarification (Advanced Clarification), and Setting Strategies and Tactics (Strategies and Tactics) (Ennis, 2011).

An effective learning process is characterized by the interaction between the teacher and students throughout the learning process, which is aware of its objectives. This interaction is rooted in the educator

(teacher) and the pedagogical learning activities within the students, proceeding systematically through the stages of planning, implementation, and evaluation. Learning does not happen instantly; rather, it progresses through certain stages. In the learning process, the educator facilitates the students to learn effectively. Through such interactions, the learning process is expected to be effective, as anticipated. School learning is expected to train students to think critically (Pane & Darwis Dasopang, 2017).

Student Worksheets are one of the learning media that can be used to improve students' critical thinking skills (Elfina & Sylvia, 2020). The use of Student Worksheets can foster good interaction between the educator and students in the learning process. Student Worksheets are sheets that contain material, summaries, and tasks that students must complete (Anggraini et al., 2016). Student Worksheets are a learning resource that can be used to nurture and develop students' critical thinking skills. These worksheets can be used to engage students actively in learning activities, developing their thinking skills. The Student Worksheet is a guide for students to conduct investigations or problem-solving

activities. The worksheets include instructions and steps to complete the tasks (Widyaningrum & Izzati, 2023)

One learning model that can be used to improve students' critical thinking skills is the Engineering Design Process (EDP). EDP is a problem-solving model that involves developing products or ideas requiring creative thinking, carried out systematically to produce a product (Winarno et al., 2020). Learning using the Engineering Design Process (EDP) can train students to analyze situations, find relevant information, define problems, develop and control ideas for solving problems, and evaluate their ideas (Sapphira et al., 2023). The design of the Engineering Design Process (EDP) model is closely related to the integration of science, technology, engineering, and mathematics (STEM). STEM offers a problem-solving approach where students are directed to understand concepts and find solutions to problems on their own (Vanesha et al., 2022). The use of the Engineering Design Process (EDP) model strengthens the application of science, technology, engineering, and mathematics within the Student Worksheets.

STEM consists of several disciplines. Below are the terms for each STEM discipline (Setiawan et al., 2020).

Table 1. STEM Literacy

Field	Literacy
Science	The ability to use scientific knowledge and processes to understand the natural world and the ability to participate in decision-making to influence it.
Technology	Knowledge of new technologies, understanding the process of developing new technologies, and the ability to analyze how new technologies affect individuals and society
Engineering	The application of science and technology through a design process using project-based learning themes by integrating several different subjects (interdisciplinary).
Mathematics	The ability to analyze, reason, and communicate ideas effectively and approach, formulate, solve, and interpret solutions to mathematical problems in their application.

STEM-based Student Worksheets can address critical thinking problems among students. The developed Student Worksheets include four disciplines: science, technology, engineering, and mathematics. The science section can train students' scientific process skills, while the technology, engineering, and mathematics sections can make students think critically and creatively (Mahjatia et al., 2021). When the Student Worksheet is combined with the STEM approach, students will have the full opportunity to identify the

problems presented and, from that identification, initiate problem-solving by creating a product (Hasanah et al., 2021).

The Engineering Design Process (EDP) model in the Student Worksheets consists of 6 stages. According to (Sulaeman et al., 2021) the six stages are: Defining the problem, Understanding the problem, Planning the solution, Testing the solution and Evaluating the solution.
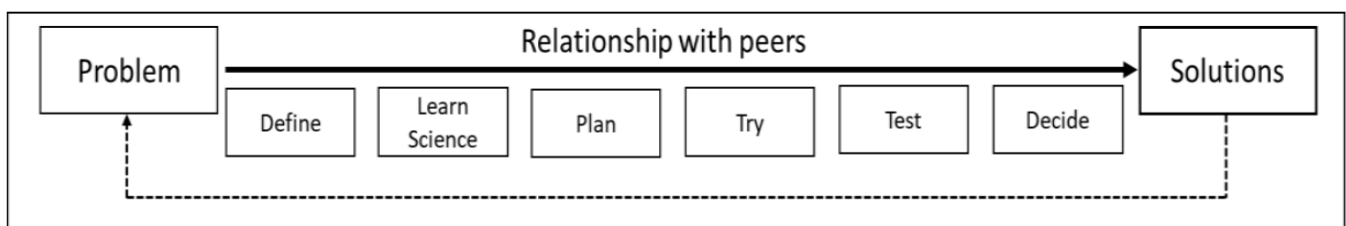

Figure 1. EDP steps

However, not all students possess satisfactory critical thinking skills. This can be seen from the lack of students' ability to solve problems given by the teacher. Students are not active in asking questions or sharing their opinions, they are hesitant or even afraid to answer the teacher's questions with their own ideas, and they are unable to solve problems on their own due to fear of making mistakes.

The development of STEM-EDP-based Student Worksheets becomes a solution to improve students' critical thinking skills at SMP Negeri 17 Samarinda.

Method

Type of Research

This research is a development study (Research & Development) using the ADDIE model developed by Robert Reiser and Michael Molenda.
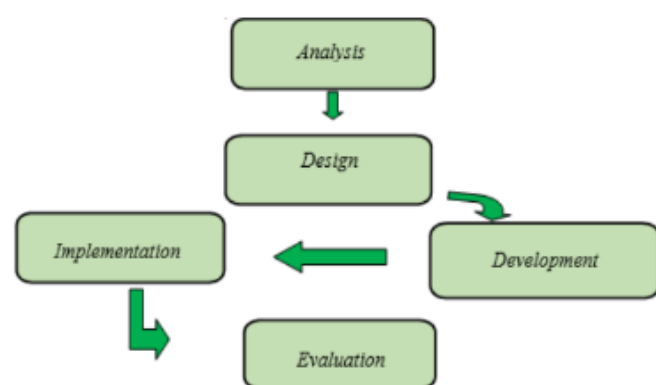

Figure 2. ADDIE development model

Time and Location of Research

This research was conducted at SMPN 17 Samarinda, located at Jl. Tatako No.24, RT.24, Sungai Kapih, Sambutan Subdistrict, Samarinda City, East Kalimantan 75011. The research was carried out during the 2024/2025 academic year, in the even semester.

Assessment Instruments

This research used instruments such as questionnaires, validation sheets, interviews, observations, test instruments, and documentation.

Data Analysis

The validity test data was obtained from expert validators through validation sheets. The practicality test data was obtained from the assessments of students and science subject teachers through questionnaires, and the effectiveness test data for the Student Worksheets was obtained from the results of the pretest and posttest

Table 2. Student Worksheets Validity Test

Validity Criteria	Level of Validity
85.01% - 100.00%	Highly Valid, or can be used without revision.
70.01% - 85.00%	Valid, or can be used but requires minor revisions.
50.01% - 70.00%	Less Valid, recommended not to be used as it requires major revisions.
01.00% - 50.00%	Invalid, or should not be used.

Table 3. Student Worksheets Practicality Test

Interval	Categories
85.01% - 100%	Very Practical
70.01% - 85%	Practical
50.01% - 70%	Less practical
1% - 50%	Impractical

Table 4. N-Gain Score Categories

N-Gain Score	Classification
N-Gain > 0.7	High
0.3 ≤ N-Gain ≤ 0.7	Moderate
N-Gain < 0.3	Low

Result and Discussion

Development of Student Worksheets

The research and development resulted in a product in the form of STEM-EDP-Based Student Worksheets. The results of the research were obtained through the procedures that have been carried out. A proper development design is required to produce a good product. Therefore, this study used the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

The first stage is the analysis stage, where a needs analysis of the students is conducted. The purpose of the needs analysis is to determine the extent to which science education is implemented at SMPN 17 Samarinda. During this stage, observations and direct interviews were conducted with the science subject teachers. The design stage is the second stage of this research. In this stage, the researcher began to design the learning media to be developed through two sub-stages: developing initial ideas and creating the design. The development stage is the third stage of this research. Based on the design concept created in the design stage, the development stage involved creating the Student Worksheets using the Canva application, with the STEM-EDP-based theme of "Ecology and Biodiversity." This was developed through various learning sources and references needed, including materials, images, and supporting illustrations to produce a STEM-EDP-based Student Worksheet. In this stage, validation was carried out by media and content experts. The implementation stage is the fourth stage in this research. After the

Student Worksheets were validated by expert validators, the learning media was then implemented in the classroom. During this stage, practicality testing of the Student Worksheets was conducted by both teachers and students. In the ADDIE model, the evaluation stage is the final stage of this research. The goal of the evaluation is to determine the quality of the developed STEM-EDP-based Student Worksheets. In this stage, the effectiveness of the STEM-EDP-based Student Worksheets in the topics of ecology and biodiversity was assessed. The assessment was carried out through pretest and posttest evaluations of the students.

Validation Test of Student Worksheets

Before the product was tested in the classroom, the first step was to analyze the validation results from the expert validators, adjusted to the educational background and expertise of the validators to ensure the accuracy of the assessment. Validation was conducted by two lecturers, one media expert and one content expert. The results of the validation of the Student Worksheets by the content and media experts are presented in Table 4.

Table 5. Results of the Validity Test for Student Worksheets

Media Expert Validation Aspects Assessed	Percentage	Criteria
Cover Illustration	100%	Very Valid
Suitability of Font Type and Spacing	91.7%	Very Valid
Clarity and Relevance of Images to the Material	83.4%	Very Valid
Suitability of Text Size with Images	87.5%	Very Valid
Text Arrangement	100%	Very Valid
Layout Appearance	87.5%	Very Valid
Content Expert Validation Aspects Assessed	Percentage	Criteria
Relevance of the Material to the Learning Outcomes	87.5%	Very Valid
Accuracy of the Material	93.8%	Very Valid
Currency of the Material	100%	Very Valid
Encourages Curiosity	100%	Very Valid
Presentation Technique	100%	Very Valid
Uses appropriate and grammatically correct language	87.5%	Very Valid
Sentences are easy to understand	87.5%	Very Valid
Development of STEM-EDP-Based Student Worksheets	100%	Very Valid

Validation of the Student Worksheet was carried out by a content expert validator. The arrangement of the content in the Student Worksheet was aligned with the curriculum used by the educational institution, based on the learning goals and objectives to be achieved. The results of the content validation by the

content expert for several aspects were: Content Appropriateness with Learning Objectives: 87.5% highly Valid, Content Accuracy: 93.8% highly Valid, Up-to-date Content: 100% highly Valid, Encouraging Curiosity: 100% highly Valid, Presentation Technique: 100% highly Valid, Use of Proper Language: 87.5% highly Valid, Sentence Clarity: 87.5% highly Valid, and Development of EDP Model Approach Steps: 100% highly Valid.

Based on the validity assessment results of the Student Worksheet above, it can be concluded that the validity test results for the media by the media expert were deemed Highly Valid, with an average percentage of 91.7%, and the content expert gave a score of 94.1%, also categorized as Highly Valid. This means the media is considered valid and suitable for testing with students in the classroom. In fulfilling the criteria for a good and suitable learning media that aligns with the learning objectives, an evaluation is necessary to test the media through validation by expert validators in their respective fields, providing an assessment of whether the product is suitable for classroom testing (Agis et al., 2021).

Practicality Test Of Student Worksheets

Next, the practicality test of the Student Worksheet was carried out based on practicality questionnaires filled out by two Science subject teachers, along with the practicality test from students of both small and large classes (VII A and VII C). The results of the practicality test are presented in Figure 2.
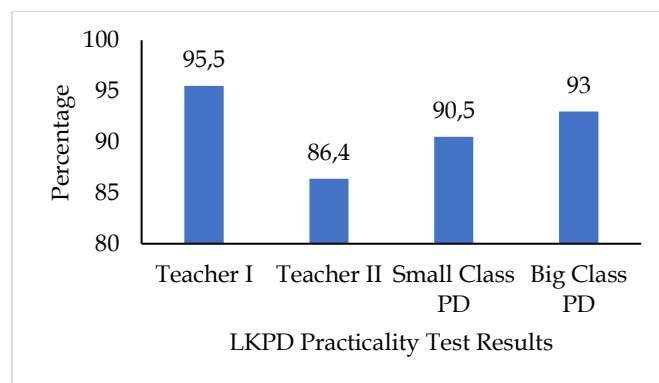

Figure 3. Results of the practicality test for student worksheet

The practicality test results by the teacher showed scores of 95.5% and 86.4%, both categorized as very practical, while the practicality test results by the students were 90.5% and 93%, also categorized as very practical. These results indicate that the developed Student Worksheets fall under the very practical category for use in classroom learning. The attractive design of the Student Worksheets, combined with the appropriate learning model, can assist students in interpreting each lesson, making it easier for them to

understand (Suwastini et al., 2022). The use of Student Worksheets can facilitate the learning process, fostering active interaction between students and educators during the learning process (Fitria & Ifdil, 2020).

Effectiveness Test of Student Worksheets

The effectiveness of the developed Student Worksheets was analyzed using SPSS 26 for Windows. The results from the Pre-test and Post-test served as the basis for measuring effectiveness, focusing on five critical thinking indicators for students: Providing Simple Explanations (Basic Clarification), Building Basic Skills (Basic Support), Making Inferences (Inference),

Further Clarification (Advanced Clarification), and Setting Strategies and Tactics (Strategies and Tactics).

The results of the normality test in Table 6 show a sig. value > 0.05. It can be concluded that the data is normally distributed and can proceed to the homogeneity test. The results of the homogeneity test can be seen in the table 7.

Based on the data in Table 7, the results of the homogeneity test show a sig. value > 0.05. It can be concluded that the data is homogeneously distributed, and the Independent Sample T-Test can then be performed. The test results can be seen in the table 8.

Table 6. Test of Normality

Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control Pretest	.153	32	.056	.937	32	.061
Control Posttest	.165	32	.027	.943	32	.090
Experimental Pretest	.178	32	.011	.939	32	.071
Experimental Posttest	.162	32	.033	.937	32	.061

a. Lilliefors Significance Correction

Table 7. Test of Homogeneity

Test of Homogeneity of Variance	Levene Statistic	df1	df2	Sig.
Mean	2.452	1	62	.122
Median	1.504	1	62	.225
Median and with adjusted df	1.504	1	61.187	.225
trimmed mean	2.393	1	62	.127

Table 8. Independent Sample Test

Levene's Test for Equality of Variances	F	Sig.	T	df	Sig. (2-tailed)
Equal variances assumed	2.452	.122	-10.306	62	.000
Equal variances not assumed			-10.306	58.870	.000

Based on Table 8, the results of the Independent Sample T-Test show a sig. (2-tailed) ≤ 0.05, indicating a significant difference in the critical thinking skills of students using STEM-EDP-Based Student Worksheets.

Next, an N-Gain Test was conducted to measure the extent of the improvement in students' critical thinking skills before and after being treated with STEM-EDP-Based Student Worksheets. The results of the N-Gain test data can be seen in the table 9.

Table 9. N-Gain Test Results

Descriptive Statistics	N	Min	Max	Mean	Std. Deviation
Ngain_Score	32	.55	.89	.7556	.07772
Ngain_Percentage	32	54.55	89.06	75.557	7.77204
Valid N (listwise)	32				

The results of the N-Gain test for the experimental class showed an N-Gain score of 0.75, which can be concluded as a high improvement in students' critical thinking skills. Critical thinking skills can be effectively trained using Student Worksheets because students are

able to provide ideas and opinions when critically analyzing the phenomena presented in the Student Worksheets. Well-designed Student Worksheets can help students to be more active in solving problems related to real-life situations (Astuti et al., 2017). Student

Worksheets can improve students' thinking skills because the questions included in the worksheets are aligned with critical thinking indicators. Each question in the Student Worksheets is designed to stimulate various aspects of students' critical thinking abilities by providing challenges that encourage students to analyze, evaluate, and solve problems in depth. This process not only develops students' intellectual abilities but also shapes a critical mindset that is essential for both the learning process and everyday life (Ramadhani, 2024).

The results of this study prove that the use of LKPD in the learning process can improve students' ability to think critically. This is in accordance with the results of research conducted by Wulandari et al. (2013) stating that Student Worksheets play a very important role in the learning process. The use of LKPD makes the learning process more focused and helps students find concepts and solve problems through activities in LKPD

Conclusion

Based on the research objectives outlined in the previous chapter and the direct research conducted in the field, it can be concluded that: 1) The STEM-EDP-Based Student Worksheets were developed based on the results of interviews and direct observations with the science subject teachers, using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. 2) The validity level of the STEM-EDP-Based Student Worksheets, based on validation by media experts, was 91.7%, and by content experts, it was 94.1%, both categorized as Highly Valid. 3) The practicality level of the STEM-EDP-Based Student Worksheets, based on student feedback, was 90.5%, and from the teachers, it was 90%, both categorized as Very Practical. 4) The effectiveness level of the STEM-EDP-Based Student Worksheets, based on pretest and posttest results, using Normality Test, Homogeneity Test, T-Test, and N-Gain Score Test, showed an N-Gain score of 0.7, which indicates a high level of effectiveness. Therefore, it can be concluded that the use of STEM-EDP-Based Student Worksheets to improve students' critical thinking skills is effective and falls under the high category.

Author Contributions
All authors ccontributed to writing this article.

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