

Development of Stem-Loaded Teaching Modules with PBL Learning Model to Improve Critical Thinking Skills of Elementary School Students

Devi Istiana¹, Fakhruddin², Harianingsih³

^{1,2,3}Graduate School, Universitas Negeri Semarang, Semarang, Central Java, Indonesia

Corresponding Author: Devi Istiana

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ABSTRACT

Critical thinking skills are the ability to solve problems by connecting knowledge in the student's cognitive system, so that they can find and choose solutions that are in accordance with the problems they face. This study aims to develop a stem-loaded teaching module with a PBL learning model to improve students' critical thinking skills.

This research adapts the ADDIE development model which is an instructional development process with 5 stages, namely analysis, design, development, implementation and evaluation.

The results of this study include: 1) Teaching module with stem content with PBL learning model; 2) The teaching module is very valid with an overall average value of the media validation test of 0.95 and the teaching module developed is very practical quality with an overall average value of the media practicality test of 95.5%; 3) The classical completeness value of the potential effect test obtained high effectiveness results with a percentage of 87%; 4) The module is declared effective with the difference between pretest and posttest scores, as well as the results of the n-gain test with an average of 0.48.

The conclusion of this study is that teaching modules with stem content with PBL learning models are effectively used to improve the critical thinking skills of elementary school students. Suggestions

from the author for the use of teaching modules in learning that will be implemented should be designed very carefully and pay attention to learning needs, the environment, facilities and infrastructure, and pay attention to the times so that the media developed can be implemented in learning properly, effectively, and efficiently. Learning about photosynthesis should often be trained in order to foster students' skills in understanding the basic concepts of IPAS so that students can think critically and simply in the environment around them. The conclusion of this study is that the teaching module containing STEM with the PBL learning model is effective for improving the critical thinking skills of elementary school students.

Keywords: teaching modules, stem, PBL and critical thinking skills

INTRODUCTION

Education is a planned effort in the learning process so that individuals can develop and grow into humans who have responsibility, creativity, knowledge, health and noble character (Inanna, 2018). The 21st century currently provides many opportunities for education to develop faster than in previous periods (Dini, 2020). One of the expectations for the education system is to be able to realize students who have critical thinking skills that are able to keep up with the times (Yamin & Syahrir, 2020; Dywan, 2020).

Critical thinking skills are one of the 21st century skills that really need to be trained because it will make it easier for students to be able to analyze and compile arguments as proof of each decision (Wahyunita & Subroto, 2021; Mareti & Hadiyanti, 2021). Therefore, critical thinking skills are a skill that students must have in stimulating cognitive reasoning and building knowledge in the learning process and are important to develop early, especially at the elementary school level (Haryani, 2021).

Critical thinking skills are the ability to solve problems by connecting knowledge in the student's cognitive system, so that they can find and choose solutions that are in accordance with the problems they face. What is included in critical thinking is classifying, organizing, remembering and analyzing various information in a problem (Metaputri & Garminah, 2019). However, in fact, teachers only direct students to the ability to memorize material. Students are not directed to understand information related to their daily lives but are only required to memorize and remember information provided by the teacher (Mareti & Hadiyanti, 2021). If students' thinking skills are low, it will have an impact on their learning outcomes.

Critical thinking skills in the learning process can make students more active, can gain broader knowledge, and are able to sort out the right information or learning resources (Mareti & Hadiyanti, 2021). Based on several studies that discuss the level of students' critical thinking skills, it is concluded that there are still students with a low level of critical thinking skills (Amran, 2022; Rizza & Madiun, 2020; Hidayat, 2019; Benyamin, 2021).

In addition, judging from the 2015 Trends in International Mathematics and Science (TIMSS) test results coordinated by The International of Evaluation of Education Achievement (IEA), it shows that Indonesia's science ability is ranked 45th out of 48 countries with a score of 397 points. According to Gandi (2021) TIMSS questions can be used to measure one of the higher

order thinking, namely critical thinking. In addition, according to Idris (2020) the aspects of understanding, application and reasoning in the cognitive domain as applied in TIMSS can be used to show the profile of students' critical thinking skills. From these results it can be said that the critical thinking skills of Indonesian students are still low. In fact, critical thinking ability is one part of higher order thinking, which plays a significant role in the learning process, especially in science subjects (Norriqqa, 2021).

The results of the preliminary study that has been carried out, related to the critical thinking skills of fourth grade students of SDN Wangandawa 02, Talang District, Tegal Regency. Based on field studies conducted by the author, the percentage of critical thinking ability of 33 fourth grade students of SDN Wangandawa 02 was 55.83%. These results are included in the low or less critical category. Students who have entered the critical category are only 2 students with a percentage of 72.5%, students who are in the moderately critical category are 6 people with a percentage of 65.41%, and students who are in the low or less critical category are 24 students with a percentage of 47.61%. The percentages on each indicator of critical thinking skills measured are: (1) Building basic skills, with a percentage of 55.27%; (2) providing further explanation with a percentage of 48.50%; and (3) providing simple explanations (Adisty, 2021) with a percentage of 60%. Therefore, it can be concluded that students' critical thinking skills in science subjects on photosynthesis material in class IV SDN Wangandawa 02 are still relatively low.

Several studies that have been conducted regarding the effectiveness of using the PBL learning model can be concluded that the PBL learning model can improve students' critical thinking skills, improve problem solving skills and can improve student learning outcomes (Mareti, 2021). The PBL model can be integrated with the science, technology, engineering, and mathematics (STEM) approach (Putri, 2020). STEM

education aims to increase students' understanding of what they are learning and so that students are able to apply this knowledge to solve the problems they face by developing higher-order thinking skills, preparing for 21st century human resource needs, and developing competencies in the STEM field (Mu'minah, 2021).

The development of STEM-loaded teaching modules with PBL learning models is considered in accordance with the current curriculum, namely the independent curriculum, STEM-loaded teaching modules with PBL learning models are able to direct students to be independent in solving problems with scientific concepts and provide space for students to carry out scientific engineering to provide solutions to the problems being faced. With the PBL learning model and STEM approach, it is expected to be able to improve students' critical thinking skills.

LITERATURE REVIEW

The following are several studies that have a relationship with this research. Research conducted by Julia (2021), Hadiyanti (2021), Widiya (2021), Yuristia (2022), Putri (2020), Fitri (2023), Mahadi (2022), Amanda (2022), based on the literature review that has been presented, it can be concluded that the application of the Problem Based Learning (PBL) learning model and the Priobliem Basied Liarning learning model with STEM content has an impact on students' critical thinking skills. In this research, the author developed a STEM-loaded teaching module with a PBL model and modified the PBL learning model that had been researched by Adiwiguna (2019) because it was in accordance with the characteristics of elementary school students. The difference between this research and the previous research is that in this research a STEM-loaded teaching module with a PBL model is developed which includes lesson plans and is equipped with learning tools in the form of student work sheets (LKPD), teaching materials, learning media and evaluation questions to support students' experimien

activities. The characteristics of the teaching modules that will be developed in this research are: (1) the learning process is oriented towards problems that are related to the process of fotosintesis in plants; (2) the learning process is student-centered (student-centered) and the teacher acts as a facilitator; (3) students conduct investigations or experiments to collect data for biophysical problem solving; (4) tiered learning is integrated with four disciplines in the STiEM approach; and (5) learning trains students' independence.

MATERIALS & METHODS

The type of research used is research and development (Research & Development) through a descriptive approach. Research and development is a research method that is oriented towards developing a particular product with stages and testing the effectiveness of the product. In this study, a STEM-fueled teaching module product will be developed with a PBL learning model to improve critical thinking skills in grade IV. After the product is developed, it is necessary to validate and test the effectiveness of the product in learning science in class IV at SDN Wangandawa 02, Talang District, Tegal Regency.

This research adapts the ADDIE development model which is an instructional development process with 5 stages, namely analysis, design, development, implementation and evaluation. According to the steps of product development, this research and development model is more rational and more complete than the 4D model. This model can be used for various forms of media and teaching material development (Winarni, 2021: 263).

The validity test of the teaching module is obtained based on the results of a questionnaire that has been filled in by media experts and material experts. The validity of this teaching module media is obtained after linguists, media experts, and material experts fill out the questionnaire that has been prepared by giving a check mark (✓) on the answer that matches the condition of the

teaching module developed. The scores in this media validity test questionnaire are 1, 2, 3 and 4 with information 1 (not good enough), 2 (good enough), 3 (good) and 4 (very good). The data obtained from the results of filling out this questionnaire is in the form of quantitative data which will calculate the average of the data with the following formula.

$$v = \sum S / [n(c - 1)]$$

Table 1 Interpretation of Teaching Module Validity

Correlation coefficient	Interpretation of Validity
$V > 0,80$	High
$0,60 \leq V < 0,80$	High enough
$0,40 \leq V < 0,60$	Enough
$0 \leq V < 0,40$	Bad

Analysis of the practicality of the teaching module is seen based on a questionnaire that will be answered by students totaling 10 questions as respondents. The questionnaire distributed to students has a score of 0 and 1 with a description of 0 (impractical) and 1 (practical) with alternative answers “Yes” and “No”. The data obtained in the form of quantitative data will be calculated to get the average score of the practicality of the teaching module from the total number of respondents. The data is calculated using the following formula.

$$P = \frac{\sum x}{n}$$

Information:

- P: Percentage of student responses
- $\sum x$: Total score for each criterion chosen by students
- n: Number of ideal scores

Table 2. Validity and Qualification Level Guidelines

Achievement Level	Qualification	Decision
81 - 100	Very good	Very Practical
61 - 80	Good	Practical
41 - 60	Enough	Less Practical
21 - 40	Not enough	Not practical
0 - 20	Very less	Very Impractical

RESULT

Assessment of the validity of stem-loaded teaching modules with PBL learning models by 1 material expert, 1 linguist, and media expert.

The material validity test was conducted by Mrs. Anisa Yuni Pertiwi, M.Pd. This material validation was carried out with the aim of knowing the suitability of the material in the stem-loaded teaching module with the PBL learning model with photosynthesis material. The validation instrument used is divided into 15 with 4 alternative answers. The score obtained in the material validation test was 58. based on these results the interpretation of the overall validity in the material validity test obtained a value of 0.95 with a high classification.

Prof. Dr. Arief Yulianto, S. E, M.M lecturer at the Faculty of Economics and Business at Semarang State University, as a language validation test expert. The instrument used in the language validity test is a questionnaire which is divided into 14 questions with 4 alternative answers. This activity was carried out once. The language feasibility test was carried out with the results of the stem-loaded teaching module with the PBL learning model developed can be used without revision. The score obtained from the language validity test is 54 with a high classification.

The third validity test was the validity of the media conducted by Prof. Dr. Tri Joko Raharjo, M. Pd as a lecturer at the Postgraduate Program of Semarang State University. The questionnaire filled in as an instrument of media validity test consists of 13 questions with 4 alternative answers. The score obtained from the media validity test was 50 with a high classification. The

conclusion from the results of the media validity test of the stem-loaded teaching

module with the PBL learning model developed can be used without revision.

Table 3 Media Validity Test Calculation Results

Expert	Amount Question	The score Obtained	Aiken V	Category
Materials	15	58	0,95	High
Linguist	14	54	0,95	High
Media	13	50	0,94	High
Average			0,95	High

Media Practically Test

The results of the media practicality test in the small group test were obtained from the results of calculations using the formula $P = \frac{\sum x}{n} \times 100\%$ so that $P = \frac{53}{60} \times 100\% = 88\%$ was obtained with very practical qualifications. In addition to the small group test, the practicality test was also applied to the field test (field testing) which was carried out on 33 fourth grade students of SDN Wangandawa 02.

The findings of the media practicality test in the field trial were obtained from the results of calculations carried out with the formula $P = \frac{\sum x}{n} \times 100\%$ so that $P = \frac{302}{330} \times 100\% = 0,91$ was obtained with very practical qualifications.

DISCUSSION

The development research produced a teaching module with stem content with PBL learning model. The ADDIE development paradigm used in this media development research includes 1) analysis, 2) planning, 3) development, 4) implementation, 5) evaluation. The process is completed so as to obtain a teaching module with stem content with PBL learning model that can be utilized by teachers in carrying out the learning process. The following section describes these stages in detail.

The validity of stem-loaded teaching modules with PBL learning models to improve critical thinking skills is obtained from the calculation of questionnaire scores of material experts, linguists, and media experts. Material validation was carried out by one expert who has understood and

experienced in photosynthesis material. The score given by the material expert was 0.95 with a high classification (very valid). Teaching modules that have been valid in terms of material illustrate that teaching modules with stem content with PBL learning models developed are suitable for use in grade IV elementary schools and the material is suitable for use in learning to improve critical thinking skills. In line with this, Radeswandri (2021) suggested that teachers can utilize teaching modules as one of the learning media to assist students in learning.

Language validation on teaching modules with stem content with PBL learning models to improve critical thinking skills, resulted in an average score of 0.95 with a high classification (very valid). Language validation on the teaching module produced was carried out by lecturers who actively teach at Semarang State University. The stem-loaded teaching module with the PBL learning model developed uses Indonesian language adapted to EYD. Jannah (2021) stated that the use of Indonesian language based on EYD in designing learning media is very helpful in facilitating readers or the use of learning media developed.

Media validation conducted on stem-loaded teaching modules with PBL learning models to improve critical thinking skills obtained a score of 0.94 with a high classification (very valid). Designing learning media for students, especially elementary school students, should display many interesting images so that students are interested and focused on the learning process. Based on the results of Mahardika's research (2021) which obtained the results of images or illustrations

should be in learning media to motivate students and foster students' curiosity about the material being taught.

The practicality of the stem-loaded teaching module with the PBL learning model was collected from a survey of student answers completed by class IV SDN Wangandawa 02 with a total of 33 students divided into 18 boys and 15 girls. Class IV students were then divided into 6 students as small group test subjects and 27 students as field trial subjects. The results obtained in the practicality test on 33 fourth grade students of SDN Wangandawa 02 with a total of 10 questions with the answer options "yes" and "no" which have a score of "1" and "0" are calculated by the formula $P = \frac{\sum x}{n} \times 100\%$ so that the overall average $P = \frac{302}{330} \times 100\% = 0,91$ is obtained with very practical qualifications.

The practicality of the stem-loaded teaching module with the PBL learning model was also obtained from the results of the teacher response questionnaire which in this study was filled in by the fourth grade teacher of SDN Wangandawa 02, The teacher response questionnaire is divided into three parts, each containing 16 questions and two alternative answers ('yes' or 'no'). The formula $P = \frac{\sum x}{n} \times 100\%$ was then used to calculate the data from the instructor response questionnaire, so that $P = \frac{16}{16} \times 100\% = 100\%$ was obtained with a very practical qualification.

Based on the above explanation, it can be concluded that the stem-loaded teaching module with the PBL learning model developed in this study is very practical with a percentage of 95.5%.

The test of the potential effect of the developed media is obtained from the results of calculating the completeness of the students' class after using the stem-loaded teaching module with the developed PBL learning model. Student completeness in the implementation of the study is guided by the KKM IPAS class IV SDN Wangandawa 02, which is 70. The student score obtained by

students > 70 then the student is said to be complete.

Based on the data from the media potential effect test results, the small group test of the developed media obtained a media potential percentage of 100%, while the field test obtained a potential percentage of 87% with each classification being very effective. This gives a conclusion that the stem-loaded teaching module with the PBL learning model has a high potential effect if used as a medium in the implementation of classroom learning.

The effectiveness of stem-loaded teaching modules with PBL learning models has moderate effectiveness to improve critical thinking skills obtained from the results of pretest and posttest data processing conducted in small group tests and field tests. The instrument used is assisted by a digital module that aims to make it easier for students to understand fraction bilangan operation material. In line with this, İlhan (2021) states that teaching modules are suitable for motivating students in learning which makes teaching modules seen as one of the practical and efficient media used anytime and anywhere.

The effectiveness test of the stem-loaded teaching module with the PBL learning model was carried out in class IV SDN Wangandawa 02 with 33 students. The first meeting was carried out by dividing students into two groups which were used as small group test subjects and field tests. Furthermore, distributing pretest questions to find out the extent to which they master photosynthesis material. After students have completed the questions given, an explanation of the media that will be used at the next meeting is carried out. The second meeting was conducted to assist students in using stem-loaded teaching modules with PBL learning models to increase their abilities regarding photosynthesis material. The average pretest score before the teaching module media loaded with stem with PBL learning model before use is 48 with a minimum score of 40 and a maximum score of 80. After the application of the teaching

module loaded with stem with PBL learning model in class IV SDN Wangandawa 02 obtained an average posttest score of 73 with a maximum score of 100 and a minimum score of 50. The data that has been obtained through the pretest and posttest of class IV SDN Wangandawa 02. then tested for data normality. The results of the data normality test obtained a score of 0.22, so it can be concluded that the data is normally distributed.

After the normality test was carried out, the data was tested with the expectation that there was a difference between the pretest and posttest results. The t-test results showed that there was a difference in student scores before and after using the stem-loaded teaching module with the PBL learning model. After data processing activities using the t test were carried out, the data obtained were calculated using the n-gain test to determine the effectiveness of using stem-loaded teaching modules with PBL learning models to improve the critical thinking skills of elementary school students.

Based on the calculation of the n-gain test on the pretest and posttest results of class V students, the average pretest score is 33 and the average posttest score of all students is 73. The data is calculated using the n-gain test formula with the calculation result of 0.48 which if qualitative becomes medium effectiveness. Based on the results of the n-gain test calculation, it is concluded that the stem-loaded teaching module with PBL learning model for improving critical thinking skills of elementary school students. In line with this Kusumadewi (2020) explains that digital modules are better than conventional books so that teaching modules are very effectively used to improve student abilities.

Teaching modules loaded with stems with PBL learning models are declared effective for improving students' critical thinking skills because there is a significant difference in the pretest and posttest results of grade IV students of SDN Wangandawa 02. The pretest value of grade IV students has an average of 48, while the posttest value of

grade IV students of SDN Wangandawa 02 obtained an average of 73. This is in line with the research of Kusumadewi (2020) and Chaidam & Poonputta (2022) which states that teaching modules and PBL learning models can have high effectiveness if used in the learning process so that the value resulting from the use of modules and learning models has increased significantly after use.

CONCLUSION

The following are the conclusions of the research on stem-loaded teaching modules with PBL learning models to improve the critical thinking skills of elementary school students:

Through the ADDIE development model which includes five steps, namely analysis, design, development, implementation and evaluation, it produces a stem-loaded teaching module with a PBL learning model that will be used in research to improve the problem solving skills of fourth grade elementary school students at SDN Wangandawa 02. The Teaching Module produced is in the form of print which is equipped with understanding, practice questions in each discussion of the material. The validity of the stem-loaded teaching module with the PBL learning model developed based on the results of the linguistic feasibility test, the feasibility of the material content, and the feasibility of the stem-loaded teaching module with the PBL learning model obtained an average score of 0.95 based on the results of the validity test of the three components. Certified High (Very Valid).

The practicality of stem-loaded teaching modules with PBL learning models is obtained from filling out student response questionnaires and teacher responses after using the developed modules. Based on the results of the two trials on the practicality of the product, the overall result was 95.5% of the maximum percentage of 100%, this states that the teaching module loaded with stem with the PBL learning model developed has

met the requirements of practicality with Very Practical qualifications.

The effectiveness of stem-loaded teaching modules with PBL learning models developed to improve problem solving skills is declared effective based on the results of paired t tests that show there is a difference in the average pretest and posttest data, and the n-gain results obtained an average of 0.48 with moderate criteria.

Declaration by Authors

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