Review Article

Implementation of MultirepresentationBased Physics Modules to Improve Students Critical Thinking Skills

ABSTRACT

Module as one of the teaching materials that can be used as an alternative in the student learning process independently. Modules are printed teaching materials that are designed to be studied independently and have a systematic structure containing learning materials, learning activities and evaluation tools to achieve the expected competencies. The results of the 1st year development research a multi-representation-based physics module to improve students' critical thinking skills that meet validity and practicality. Multirepresentation is the presentation of the same material in different forms of delivery, which can be in verbal, mathematical, pictorial and graphic forms. The purpose of this study is to describe practicality including the implementation of learning, student activities, obstacles that arise. In addition, effectiveness includes critical thinking skills and student responses to the application of the module. The type of research used is Research and Development (R & D). The development model design used is the development model by Thiagarajan, namely the 4-D development model, which consists of four stages of Define, Design, Develop, and Disseminate. The research was carried out in the Even Semester of the 2022/2023 Academic Year on the work andenergy. Extensive trials or dissemination were carried out at high schools in the former Besuki residency with research subjects from class X high school students. Collecting data in a study, namely questionnaires, interviews, observations or observations, tests and documentation. Critical thinking indicators include interpretation, analysis, evaluation, inference, explanation, and self regulation. Seeing the importance of this, multi-representation-based physics modules still require an implementation test by conveying concepts and implementing steps as teaching materials that explain one unit in a coherent and precise manner. Therefore, there is a need for further research on implementation to describe practicality including the implementation of learning, student activities, the obstacles that arise. In addition, effectiveness includes critical thinking skills and student responses to the application of multi-representation-based physics modules.

Keywords: Module, Physics, Multirepresentation, Critical Thinking

1. INTRODUCTION

Critical thinking and problem solving demonstrates the ability to express reasons effectively, use systems thinking, analyze, evaluate, synthesize to make the right decisions in finding the best solution for solving a problem. Communication and collaboration shows the ability to convey information, orders, motivation and invitations well and can work with other individuals in the team [1]. Creativity and innovation demonstrate the ability to develop, implement and communicate new ideas that are original, effective and applicable, useful and useful for life [2].

Module as one of the teaching materials that can be used as an alternative in the student learning process independently. Modules are printed teaching materials designed to be studied independently and have a systematic structure containing learning materials, learning activities and evaluation tools to achieve the expected competencies [3]. The difference between modules and other teaching materials is that modules can be used for independent study by students so that modules must be arranged systematically, using easy languages and containing clear steps and instructions for students to understand [4].

The results of the 1st year 2021 development research Decree of the Chancellor of the University of Jember concerning Determination of Research Grantees for Professor Productivity at the University of Jember, namely multi-representation-based physics modules to improve students' critical thinking skills that meet validity and practicality. It shows that expert and user validation of multi-representation-based physics modules achieving an average score of ≥ 93% is in the valid category which includes: content, construct, and face validation so that it is feasible to apply in learning. The practicality of multi-representation-based physics modules shows: (1) the implementation of an average value of < 3.6 is in the very good category; (2) student activities that are relevant to the multi-representation-based physics module with an average value of <85% are in the very active category; and (3) the obstacles that arise during the learning process of multi-representation-based physics modules have appropriate alternative solutions so as to improve students' critical thinking skills. Development provides benefits and makes it easier for teachers to convey physics subject matter and optimize student learning outcomes.

The emphasis on learning Physics through multi-representation is very important to do to help and familiarize students in solving Physics questions. Multirepresentation is the presentation of the same material in different forms of delivery, which can be in verbal, mathematical, pictorial and graphic forms [5]. So far, physics learning has not emphasized important representations in the delivery of material. Even though the delivery of using multi-representation in learning Physics will greatly help students' understanding in capturing material and can improve students' critical thinking skills [7].

Critical thinking ability is one of the demands in 21st century learning. There are six core indicators of critical thinking skills involved in the critical thinking process. Critical thinking indicators include interpretation, analysis, evaluation, inference, explanation, and self regulation [7]. Therefore, training students to think critically is needed in the learning process so that students can face and answer the challenges of the future. Research shows that there is a close relationship between critical thinking and problem solving, namely the ability to solve problems requires the ability to think critically in finding alternative ways to find solutions [8].

Seeing the importance of this, multi-representation-based physics modules still require an implementation test by conveying concepts and implementing steps as teaching materials that explain one unit in a coherent and precise manner. Therefore, there is a need for further research on implementation to describe practicality including the implementation of learning, student activities, the obstacles that arise. In addition, effectiveness includes critical thinking skills and student responses to the application of multi-representation-based physics modules.

2. LITERATURE REVIEW

Learning is a process of change that is carried out consciously intended for a systematic activity in order to create a change from students towards something better. During the learning process, students will be involved in various things related to learning [9]. Learning activities cannot run without having clear and directed goals. Learning is an activity of seeking knowledge, skills and positive values carried out by someone by utilizing various sources for learning. Learning is a process of interaction between students and teachers, teaching materials, delivery methods and strategies as well as learning resources in a learning environment [10]. From the above understanding it can be concluded that learning physics is an activity or process of seeking knowledge, skills and positive values about facts, concepts, principles and the discovery process of natural phenomena that can be observed and measured systematically through interactions between students and various learning sources including teachers. , books, the environment, and the internet.

Modules are printed teaching materials that are designed to be studied independently and have a systematic structure containing learning materials, learning activities and evaluation tools to achieve the expected competencies. Five characteristics of a module that can increase learning motivation, namely: Self-instructional (independent learning), namely students can use the module to study

independently, self-contained (intact unit), namely learning material from a competency or sub-competence studied contained in one module intact. Stand alone, namely modules that are developed not depending on other teaching materials, adaptive, namely modules that have adaptive power to the development of science and technology, user friendly, namely modules that are easy to use by students. The use of language that is simple, easy to understand, clear instructions and information will make the module used easy for students to use [11].

Multirepresentation is representing the same concept in different formats, verbally, in pictures, graphically and mathematically. Multirepresentation has three main functions, namely as a complement, limiting interpretation, and building understanding. Multirepresentation is the presentation of the same material in different forms of delivery, which can be in verbal, mathematical, pictorial and graphic forms [12]. Multirepresentation is a modeling framework using multiple representations in learning physics. This is done because of the challenges in delivering physics subjects which have certain characteristics. Physics as a science subject studies natural phenomena and physical events in everyday life that are explained logically and in mathematical form. Likewise with physical objects, starting from the atomic scale studying elementary particles that cannot be seen up to the macrocosmic scale studying the vast and vast universe. In general, multirepresentation is divided into four representations, namely verbal representation, mathematical representation, graphic representation, and image representation [13].

Critical thinking is a thinking activity that includes, among others, classifying, organizing, remembering, and analyzing information from various points of view. Critical thinking can also be defined as reasonable thinking to decide what to believe or do. Critical thinking is part of a complex process that requires higher cognitive skills in processing information [14]. Critical thinking is reflective thinking that makes sense and focuses on deciding what to believe or do. Critical thinking is self-regulation in deciding something that results in interpretation, analysis, evaluation, and inference, as well as exposure using evidence, concepts, methodologies, criteria, or contextual considerations on which decisions are made [15].

3. METHODOLOGY

3.1 Types of Research

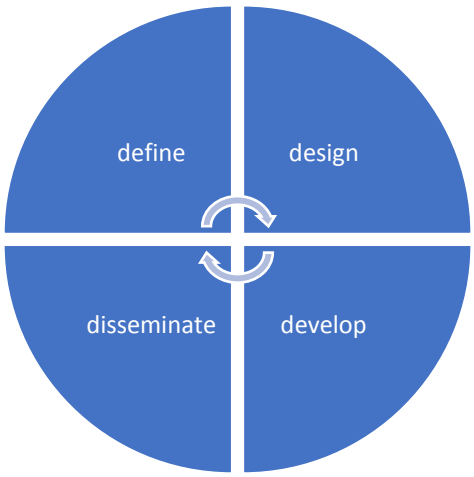
The type of research used is Research and Development (R & D) [16]. This study aims to produce a product in the form of a multi-representation-based Physics module to improve students' critical thinking skills. The development model design used is the development model by Thiagarajan, namely the 4-D development model, which consists of four stages of Define, Design, Develop, and Disseminate [17].

3.2 Time, Place, and Research Subjects

The research implementation plan is to be carried out in the Even Semester of the 2022/2023 Academic Year on the material Energy. Extensive trials or dissemination were carried out at high schools in the former Besuki residency. The subject of the research is the development of multi-representation-based Physics modules to improve the critical thinking skills of class X high school students.

3.3 Research Stages

The research stages use the steps according to the 4-D development design.



Picture 1 : 4-D development design

The product developed is a physics module based on multiple representation to train students' problem solving skills on work and energy material. The validity test was carried out using an expert judgment sheet with 4 aspects, namely aspects of media, content, presentation and language. The assessment criteria for research instruments can be seen in table 1.

Tabel 1. Criteria Expert assessment of research instruments

criteria	score
Perfect fit (SS)	4
In accordance (S)	3
It is not in accordance with (TS)	2
Very Inappropriate (STS)	1

3.3.1 Define

The defining stage is the stage used to determine the needs in learning: 1) The initial-late analysis was carried out by making observations through distributing questionnaires to high school physics teachers; 2) Student analysis was carried out by making observations in the form of filling out questionnaires by students to find out students' thinking processes, information absorption, and the application of multirepresentation in the process of learning Physics in class; 3) Task analysis was carried out by analyzing the Core Competency and Basic Competency of the 2013 Curriculum for physics class X even semester; 4) Class high school physics materials in the even semester study Newton's Laws, Gravity, Work and Energy, Momentum and Impulse, and Harmonic Vibration. Each chapter has its own characteristics in the delivery of learning material; and 5) The formulation of learning objectives is carried out by identifying which are formulated in the competency achievement indicators.

3.3.2 Design

The results of the product design to be developed are in the form of an initial design of multiple representation-based e-modules to train students' problem solving. The module is prepared based on the design described in the previous chapter which consists of: cover, author identity, preface, core competencies and basic competencies, instructions for use, content components (concept maps and learning activities), glossary, bibliography and answer keys.

3.3.3 Develop

The validation carried out by this validator serves as input for improving the initial draft of the module that has been made. Revision is the next stage after module validation is carried out by the validator. Input from expert/expert validation will be used as input for revising the draft 1 module that was made. Module products that have been revised into draft 2 modules will then enter the trial phase.Product trials in this study were carried out twice, namely small class trials and limited class trials. Expert test calculations for media aspects can be seen in table 3.

3.3.4 Dissemination

In the final evaluation, a final check is made of the final product of the module to be disseminated as well as the selection and suitability of schools that will be the target of distribution.This packaging aims to give students interest in learning the contents of the module and make the module neater.At this stage dissemination was carried out in three schools which had three different conditions both in terms of school infrastructure and students.

3.4 Data collection technique

There are several techniques that can be used to collect data in a study, namely questionnaires, interviews, observations, tests and documentation. [19].

3.5 DataAnalysistechnique

Analysis of the practicality of the module can be seen from the results of the data analysis of the observation of the implementation of learning by the teacher and the student response questionnaire in using the multi-representation-based Physics module [20]. Student response is social reactions carried out by students or students in response to influences or stimuli within themselves from repetitive situations carried out by others. mImproving students' critical thinking skills is done by analyzing the pre-test and post-test results data calculated for each indicator N-gain [21].

4. RESULTS AND DISCUSSION

Module feasibility assessment is an activity to assess whether the developed module is suitable for use or not. The module validation process is carried out with the aim of improving the module based on expert judgment in the form of checklists and comments or suggestions that produce modules that are suitable for use as teaching materials. The module assessment consists of two components, namely the eligibility of the material and the eligibility of the media. The results of the assessment are presented in Table 2.

Table 2Module Feasibility

Rated aspect	Score	
	Expert Lecturer	Physics Teacher
Content Eligibility	10	11
Language	9	10
Serving	13	13
Display screen design	9	10
Operation	3,5	3
Consistency	10	10
Format	7	7
Benefits	9,5	9
Total score	78,5	79

The validation results by the Physics teacher on the content feasibility aspect obtained a score of 11 so that a percentage of 91.7% was obtained with a score of 3.67 in the good category. The linguistic aspect obtained a score of 10 so that a percentage of 83.3% was obtained with a value of 3.33 in the fairly good category. The presentation

aspect obtained a score of 13 so that a percentage of 81.3% was obtained with a value of 3.25 in the fairly good category. The graphical aspect obtained a score of 10 so that a percentage of 83.3% was obtained with a value of 3.33 in the fairly good category. The screen design display aspect obtained a score of 6 so as to obtain a percentage of 75% with a value of 3.00 in the good category. The aspect of ease of operation is obtained with a score of 3 so that a percentage of 75% is obtained with a value of 3.00 in the fairly good category. The consistency aspect obtained a score of 10 so as to obtain a percentage of 83.3% with a value of 3.3 in the pretty good category. The format aspect obtained a score of 7 so that a percentage of 87.5% was obtained with a value of 3.50 in the fairly good category. Aspects of expediency obtained a score of 9 so as to obtain a percentage of 75% with a value of 3.00 in the pretty good category.

Data from student responses, module has 4 aspects, namely content feasibility aspects, linguistic aspects, design aspects, and media interaction aspects. The feasibility aspect gets a percentage of 85.6% with a good classification. The linguistic aspect gets a percentage of 83.6% with a good classification. The design aspect gets a percentage of 84.9% with a good classification. The aspect of media interaction gets a percentage of 82.6% with a good classification.

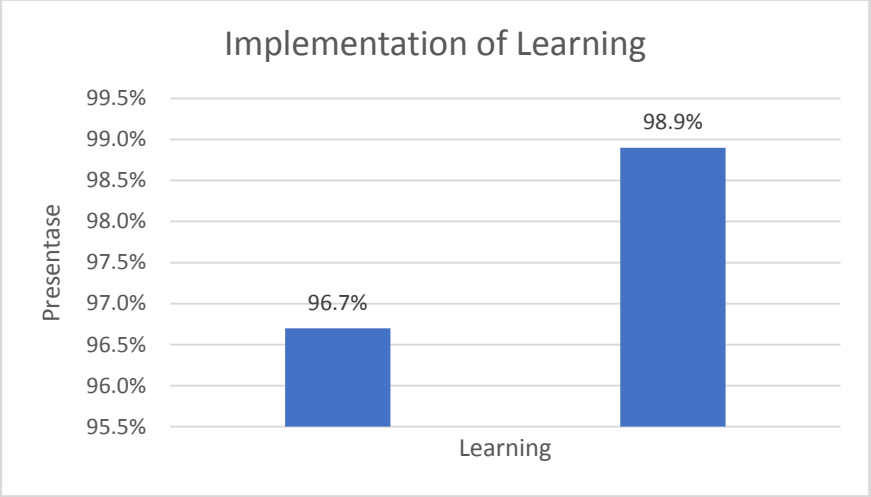


Figure 1. Implementation of Learning

The data on the results of the implementation of learning in Figure 1 were obtained from two observers at each meeting. The first meeting obtained a percentage of 96.7% and the second meeting obtained 98.9%.

Table 3. Data on the Results of the Application Stage Critical Thinking Ability Test

Stages	Amount	Average
Pre-test	1195	33,19
Post-test	2645	73,47

The stage of applying the results of the pre-test shows the average value of 33.19 and the post-test value shows the average value of 73.47 obtaining a gain criterion of 0.602 in the medium category because the gain value is included in the criteria of normalized gain $0.3 \geq g \geq 0.7$.

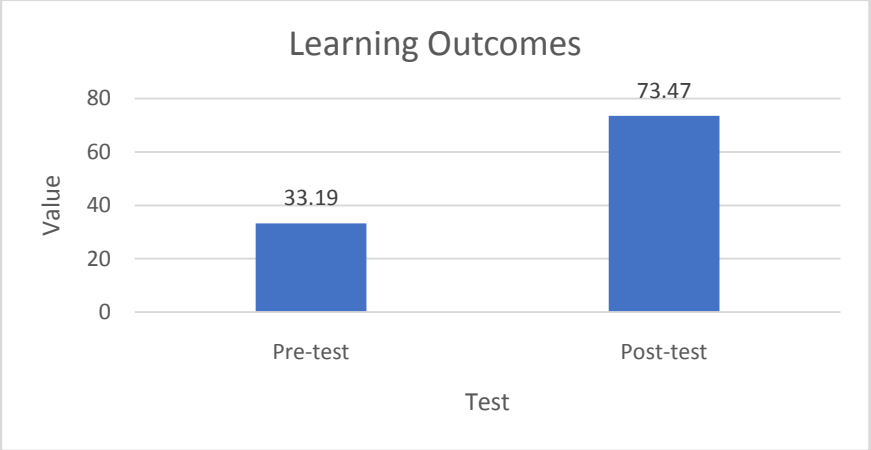


Figure 2. Pre-test and post-test results

Based on the results of the research, there is an increase in student learning outcomes using the developed teaching materials. The increase can be seen from the results of the pretest and posttest. These results are in line with studies where students find it easier and more interesting to learn than they have to open a printed book. Practical and effective reasons can be seen from the results of the implementation of learning and the responses of students. This tendency is in line with studies where students tend to learn more easily and learning outcomes increase relatively better than conventional learning with printed books or using presentation media.

5. CONCLUSION

Based on the data obtained at the development stage, it can be concluded as follows: (1) the validity of the multi-representation-based module is included in the fairly valid category, (2) the ability of students' multi-representation which can be concluded in this study is in the high category, (3) student responses obtained in the study this is positive for all aspects. Design stage, the design consists of: module cover, author identity, preface, core competencies and basic competencies, instructions for use, content components which are concept maps and learning activities that contain 1) learning objectives, 2) descriptions the material contains multiple representations, especially image representations, besides that it also consists of verbal representations, graphic representations and mathematical representations, 3) summaries, 4) student activity sheets, 5) practice questions and evaluation questions that train students' problem solving skills , glossary, bibliography and answer key. The design of the instrument for evaluating the module is made according to the grid contained in the previous chapter. After the design stage which has been assessed by the supervisor and then revised, the next stage is develop, which is validating the module and revising it based on the validation results. The end result of this study is a physics module based on multiple representation to train students' problemsolving skills on work and energy material.

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