

Development of Comic-Based Physics Modules to Improve Students' Critical Thinking Ability on Vibration and Wave Materials

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Abstract – This development research will produce a product in the form of a comic-based physics module on vibration and wave material. The research objectives are to determine: (1) Feasibility, (2) practicality, and (3) the effectiveness of the module to improve students' critical thinking skills. The research uses Research & Development which refers to the development of ADDIE namely Analysis, Design, Development, Implementation and Evaluation. The analysis and design stages are developed based on the needs of students by displaying the discussion of comic characters which aims to make students able to think critically. The product validation stage involves 4 validators, namely two media experts and 2 material experts to assess the module design, material feasibility, and language feasibility. The results of the validation of the feasibility of the module obtained 82% from the 2 media experts and 82% from the 2 material experts--all of which were within the category of "Very Valid". The implementation phase was carried out at SMP Negeri 2 Wagir with 26 students of class VIII as the subject. The results of the study are: (1) the practicality of the module is 93% within the "Very Positive" category for the 26 student responses, while for the physics teachers, it is 95% within the "Very Positive" category; (2) the effectiveness of the module is indicated by an increase in students' critical thinking skills with an N-gain of 0.68 under the "Medium" category of improvement. Thus, it can be concluded that the comic-based physics module produced in this study is suitable for use in learning vibration and wave materials.

Keywords: Learning Module; Comic; Vibration and Waves; Critical Thinking Skills.

INTRODUCTION

Education must be able to support children's thinking skills so that the next generation is able to prepare themselves to face advanced technology or the so-called Industry 4.0 (Wakhidah et al., 2020). The vast progress of the change of times will lead humans to the era of the industrial revolution 4.0. This gave birth to a fundamental transformation of human life (Wakhidah & Sunismi, 2020).

Innovative and interesting teaching materials are needed to incorporate technological advances into learning. Through the provision of material accompanied by pictures of relevant student life, students will be actively involved in the

learning process. The practice questions in each chapter can be completed individually or in groups using teaching materials that include evaluations in the form of independent assignments (Sukerni, 2014). In order for learning to be more meaningful, there needs to be an interaction between students and teachers, students and students, and students with learning materials (Ditasari et al., 2013). Every educational activity is expected to function as teaching material, helping students better understand the material and facilitating an efficient learning process (Novitasari, et.al., 2016).

Module is one type of teaching material used to assist educators or teachers in carrying out teaching and learning activities (Nugraha

et al., 2013). Modules are types of teaching materials that are systematically arranged in a language that is practically understood by students based on their level of knowledge and age (Prattowo 2015). This allows students to learn on their own (independently) with little guidance from the instructor. Students must be able to achieve mastery learning to benefit from effective organization of material in modules (Irawati, 2015). The learning modules developed today are more effective and simpler in learning (Sudjana, N., Rivai, 2015). The form of textbooks causes the learning process to still be teacher-centered, and results in low student learning outcomes (Ningsih, 2012).

Based on the results of the initial needs questionnaire at SMP Negeri 2 Wagir grade 8, the researchers found that students were more interested in more interesting teaching materials. Providing interactive modules can make students more interested in learning (Siamy et al., 2020). Physics subjects often include abstract ideas (Santi & Agus, 2018). Utilization of relevant and interesting teaching materials is one strategy to develop critical thinking skills (Nopitasari, 2019). Students can benefit greatly from developing their critical thinking skills, concentration, and analytical thinking skills.

Comics can be described as a type of cartoon character who tells a story (Sudjana & Rivai, 2015). Comics are one of the visual communication media that can convey information in a popular and easy-to-understand way. Comics are a creative medium that combines text and images (Mediawati, 2010). Information is more easily absorbed when written and visual elements are woven into an image storyline (Waluyanto, 2021).

Comic-based learning modules can

improve student learning outcomes (Febriandika, 2016). Comic media has the potential to improve students' cognitive learning processes (Hadi & Dwijananti 2015), have a significant impact on student achievement (Enawati & Sari 2012) and can increase students' learning motivation (Handoko, 2018). Students' ability to argue is influenced by the development of comic-based modules (Lubis, 2018)

This study develops a comic-based physics module to improve students' critical thinking in the discussion of vibrations and waves. The purpose of this study was to determine the feasibility, practicality, and effectiveness of the module implemented at SMPN 2 Wagir, Malang Regency, East Java. This comic-based physics module is considered very important because it can motivate students to learn so as to improve students' critical thinking. The novelty of the research can be seen from the design of the comic-based physics module on Vibration and Wave material, whereby so far, the material is in the form of narration and images.

RESEARCH METHOD

This study uses the R&D (Research and Development) method which was developed with the ADDIE model. The R&D development research method is a scientific way of researching, designing, producing and testing the validity of products that have been designed (Sugiyono, 2013). There are five steps in this model: analysis, design, development, implementation, and evaluation, which are shown in Figure 1.

The ADDIE model was developed during the development phase. The characteristics of the students and the progression of the module are the focus of the initial analysis. The product's design or design

is the designer's second stage. Module development, the creation of assessment instruments, expert validation, and revision are the three stages of development. The application of the validated revised module as material for module refinement is the fourth stage of implementation. The module is evaluated in the fifth stage of evaluation to provide feedback on the modules that have been developed and to examine the implementation results.

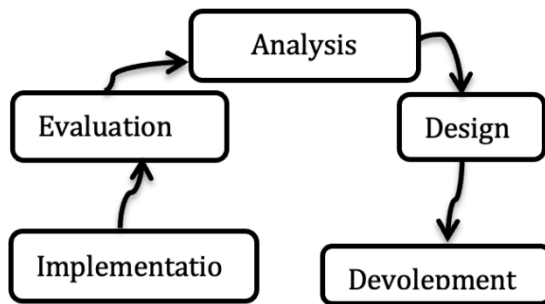


Figure 1. ADDIE Developer Model

Validation analysis on the module is used to test the feasibility of learning materials and media. The indicators developed for the feasibility of the material are: 1) Feasibility of content, 2) Feasibility of language, and 3) Presentation. While the indicators of media feasibility are: 1) product design, 2) consistency, 3) attractiveness, 4) format, 5) usability, and 6) graphics. The assessment validation score consists of 4 scales, namely: (1: not good, 2: not good, 3: quite good, 4: very good), with reference to the criteria in Table 1 (Khamzawi & Wiyono, 2015).

Table 1. Product Eligibility Criteria

No	Value	Criteria
1	80% - 100%	Very Valid
2	60% - 80%	Valid
3	40% - 20%	Less Valid
4	20% - 40%	Fairly Valid
5	0% - 20%	Invalid

Source: (Khamzawi & Wiyono, 2015)

The first stage of this development research is to conduct research needs analysis. Interviews were conducted on students at SMPN 2 Wagir class VIII. The results of the analysis of student needs are needed to consider the development of comic-based physics modules. After conducting the analysis phase and knowing the student's learning needs, the next phase is design or designing products. The steps taken in designing comic-based physics module products used the Gacha Life application. The product is designed in the form of printed media (print-out) in the form of a book. The description of the material begins using prior knowledge and phenomena that are often encountered by students in everyday life. This is to stimulate students' curiosity about the module to be studied. The module contains details ranging from cover to glossary to support students' independent learning. The material is completed with illustrative images and explanations of questions that direct students to be able to understand the material critically. In addition to the complete material, there is an evaluation at the end of the lesson in the form of practice questions and simple experiments contained in the LKPD (Student Worksheet).



Figure 2. Example of a Comic-Based Module Design

Product Trial

Comic learning modules that have been developed and validated by material and media experts will be put to test at SMP Negeri 2 Wagir, Malang Regency. This research trial involved 26 students in class VIII Integrated Science during the even semester of 2021/2022. The instruments of the research included tests of critical thinking skills, module effectiveness sheets, media expert validation sheets, and material expert validation sheets. The validity, efficacy, and practicality of the comic-based learning modules were explained using qualitative data analysis techniques.

RESULTS AND DISCUSSION

Results of Module Development

A book-shaped product design has emerged from the development phase. In order to ascertain the module's viability during the development stage, material and media experts perform validation. There are two experts who evaluate the media and two experts who evaluate the content. The Physics Education program at University of PGRI Kanjuruhan Malang is taught by the four experts.

a. Validity of Comic Based Module

The content and the presentation of the material's content are the two aspects that material experts consider when validating learning modules. The content aspect includes

a number of indicators, including the material's compatibility with competency standards and basic competencies, its accuracy, its upkeep, and its ability to pique students' curiosity. In terms of the aspect of presentation, there are five indicators: coherence, coherence in the flow of thought, presentation support, learning presentation, and presentation techniques. The results of the material validation can then be seen in Table 2.

According to the material expert research data on module development, the comic-based physics module to improve students' critical thinking on vibration and wave material received an average score of 3.35 and was included within the "Valid" category with an eligibility percentage of 83%. Module development receives suggestions and related input in addition to the evaluation of material experts. A follow-up is carried out in the form of revisions or enhancements to the student critical thinking comic on the subject of vibration and waves developed, based on the data obtained in the form of suggestions and comments from experts. Materials, discussion questions, sample questions, and practice questions that are tailored to the critical thinking indicator (High order Thinking is equivalent to C4-C6 in Bloom's taxonomy) are among these enhancements.

Table 2. Research Data of Material Experts.

No	Indicator	Expert I	Expert II
1.	Content Feasibility		
	Compatibility of comic with basic competencies and indicators	4	4
	Compatibility of comics with module material	4	4
	The ability of comics in the module to improve critical thinking	2	3
1.	Feasibility of the language of		
	Truth and accuracy of the terms used	3	4
	Conformity with General Guidelines for Indonesian Spelling (hereinafter PUEBI) rules	3	3

No	Indicator	Expert I	Expert II
	Use of language effectively and efficiently	3	4
2. Presentation			
	The use of fonts (types and letters) and layout	3	
	Illustrations, pictures, graphics	3	4
	Display design	3	4
	Discussion questions presented can increase student inference	2	3
Material Expert Score		30	37
Total Score		67	
Average		3,35	
Percentage		83%	

Media professionals validate modules on the variety of the design, consistency, comical appeal, format, usability, and graphic elements. Aspects of product design that display indicators include the precision with which the size of the shape or typeface is selected and the composition of the color of the writing on the background. Meanwhile, consistency is viewed from aspects such as font size and shape, word, term, sentence consistency, and layout consistency. Interesting aspects of comics show how well the characters were chosen and how

appropriate language was used, making it easy to understand. The format aspect, which includes indicators of writing accuracy, layout, and format module page, is evident. Aspects of usability includes indicators of helping students learn, keep their attention on one thing, and differentiate between their own abilities. Graphic aspect includes indications of consistency between text and images, writing readability, image size, and cover's attractiveness. Table 3 displays the data from the validation results.

Table 3. Research Data of Media Experts

No	Aspect	Indicators	Experts I	Experts II
1	Product Design	Accurate selection of shape/typeface sizes	3	4
		Accuracy of writing color composition against writing background	3	4
2	Consistency	Of the shape and size of letters	3	4
		Consistency of words, terms and sentences	3	4
		Consistent layout	3	3
3	Interesting comics	Accuracy in choosing comic characters	3	4
		Use of language that is easy to understand	3	4
4	Formatting	Accuracy in writing layout	3	3
		The module page format is clear	3	4
5	Usefulness	Facilitates learning	3	4
		Provides focus of attention	2	4
		Distinguishes individual abilities	3	3
6	Graphical compatibility	Between text and images	3	3
		Readability of the writing	3	4
		Image size	2	4
		Attractiveness of the cover	3	3
Media Expert Score			46	59
Total Score			105	
Average			3.28	
Percentage			82%	

The development of a comic to enhance students' critical thinking on vibration and wave material, which received an average score of 3.28 and a feasibility percentage of 82%, is categorized as "Valid" according to data from media experts' research. In addition to the evaluation of media experts, module development-related suggestions and input are provided. A follow-up in the form of revisions or enhancements to the comic developed to improve students' critical thinking on vibration and wave material is based on the data obtained in the form of suggestions and comments previously obtained from material experts. These enhancements include using the original image rather than cropping it, attempting to fill every page with content (no gap in the module), and reducing the caption below the image.

b. The Practicality of Comic-Based Modules

Data from student and teacher response questionnaires and device implementation observation sheets were required to demonstrate its practicality. Using a questionnaire, data from students' and teachers' responses to the questionnaire were gathered. The assessment is used to evaluate the usefulness of happy response modules and applications, as well as the module presentation, illustration/design drawings, practice questions, and ease of learning the material in comics. It is translated into statement indicators that are simpler for students to understand and fill out from the existing aspects. Table 4 provides a summary of the average responses from class VIII students at SMP Negeri 2 Wagir for each aspect of the assessment.

Table 4. Student Responses

No	Aspect	Indicator	Average Score
1	Response happy	Availability based modules <i>comic</i>	3.73
		Response happy to use-based module <i>Comic</i>	3.76
2	Ease of learning the content of comic	material The material presented is easy for students to understand	3.69
		Comic-based module is easy to learn and understand	3,53
3	Module presentation	Display of <i>comic</i>	3.88
4	Illustrated images/ design	Creative and innovative design	3.76
		Illustrations presented relating to daily life	3.92
5	Practice Problems	Understanding the discussion	3.65
		Answers	

The results of the response to the development of comic students' critical thinking on material vibrations and waves can be seen in table 4. The indicator explains how students reacted after using the product in the happy response aspect. The indicator comics' aspect of ease of learning the material demonstrates that the module's content is straightforward for students to comprehend. The comic's appearance is described in the indicator module's presentation aspect. The

presentation of the modules' design is explained through aspects of illustration image and indicator design. In addition, the indicator questions' practice component demonstrates that students can comprehend the discussion of answers.

A response from the subject teacher is also required, in addition to the response from the student to the developed module. The response is used to assess the practicality of the module's three-dimensional visualization

applications for content, language, and practicality feasibility. The teacher will then use assessment indicators to evaluate the media to describe these aspects. The physics

teacher for class VIII gave the media an evaluation by the teacher. Table 5 displays the teacher's assessment findings.

Table 5. Teacher's Response to Comic-Based Modules

No	Aspect	Indicator	Score
1.	Feasibility of content	Accuracy of objectives in the module with the material presented	4
		The problems presented reflect events from everyday life	4
		The material presented includes concepts on the subject matter of vibrations and waves	3
		Practical activity sheets help solve the problems presented	4
		Example questions given are in accordance with the material presented	3
		Practice questions are presented at the end of the material	4
		Instructions make it easier to understand using the module	4
2.	Feasibility language	Structure used in problems in accordance with EYD	4
		The material is presented using language that is easily understood by students ⁴	4
		The language used in the material does not cause misconceptions	4
		The language used does not create multiple meaning questions so that it confuses students	4
3.	Practicality	The learning module is easy to use anywhere	4
		Modules can help students to be active in the learning process	3
		Modules are interesting and not boring	4
		Modules are interactive	4
Total Score			57
Average			0,95
Percentage			95%

The response of the teacher to the comic-based module, as shown in Table 5, with an average score of 0.95 and a percentage of 95%. The indicator's content provides an explanation of the module's feasibility assessment in terms of the aspect of feasibility. The evaluation of the language structure is explained by the indicator's feasibility component, while the indicator's practicality component explains the module's user comfort, its attractiveness, and its role in the teaching and learning process.

c. The Effectiveness of Comic-Based Modules

Figure 3 shows that 26 students' abilities were improved through pretest and posttest evaluations, which can be divided into two categories. In the medium category, there are 11 students, and in the high category, there are 15 students. An increase in critical thinking abilities can be a sign of a product's effectiveness; this can be measured by

evaluating the product before and after use. The evaluation has grown to the point where it is possible to conclude that the module is useful for studying.

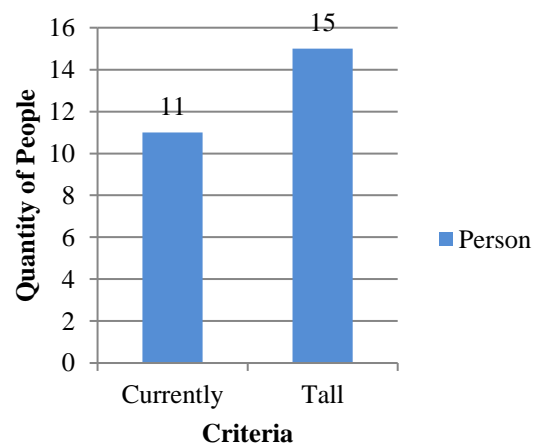


Figure 3. Results of Increased Critical Thinking Ability

Discussion

The teacher-centered learning approach is to blame for students' poor critical thinking

skills (Ratnawati et al.,2020). Students become dependent on teachers and textbooks as learning centers as a result (Siamy et al.,2020). This is backed up by research (Puspitasari, 2019), which says that students' critical thinking skills can be improved by using independent teaching materials in the form of modules to enhance their learning experiences. According to research (Novtiar & Aripin, 2017), the only teaching material in various schools is the use of modules by teachers. These modules only present routine questions and explain how to solve them using the formulas that have been provided, so they do not teach students to think critically about mathematics. Additionally, this study is comparable to Sang's (Madroji et al.,2019), namely that in addition to the way textbooks are presented, they are frequently continuous and verbalistic, making it difficult for students to learn them. In this development study, critical thinking ability was measured using the results of a pretest and posttest evaluation of students' learning. Pretests were administered to students prior to module study, while posttests were administered after module study. According to Rajendran (2001), the questions also make use of the cognitive domain (C4-C5) and the idea of High Order Thinking Skill (HOTS). The research by (Herawaty et al.2019), in which it was stated that HOTS is the capacity of students to critically evaluate data, draw inferences, and make generalizations.

a. Feasibility of Comic-Based Modules The

According to validators (Sugiyono, 2013), design validation is an activity process to assess whether the product design is feasible. In this case, the new teaching method will rationally be more effective. The

feasibility of the product that will be used to determine whether the module is feasible or not is observed from the validation results. Media experts and material experts are professors at Universitas PGRI Kanjuruhan Malang's Physics Education program who are knowledgeable about and experienced in media development. The student module and teaching module were first submitted to the validator by the researcher before being validated. A questionnaire is the instrument that is used, and the type of data that is expected is quantitative data, which means an evaluation of the module, while experts' advice is used to get qualitative data. The validator validates the developed module in order to gather feedback and suggestions. Through a validity evaluation sheet, the validator provides an evaluation of the product's media and materials. Before being used in the field, the module is revised using input from the validator.

In terms of the feasibility of presenting media on comic, the main discussion of vibration and waves is suitable for use with revisions, and the results of the media expert assessment obtained an average score of 3.28 and a percentage of 82% that was included in the "very valid" category. Then, according to Setiawati (2013), modules that scored very well could be used in trials. The material validation analysis yielded an average score of 3.35, placing it in the "very good" category, and the percentage of presentation feasibility was 83%, placing it in the "very valid" category. As long as the presentation of a comic book about waves and vibrations can be used with revision, According to Syutharidho & Rakhmawati (2015), these experts' evaluations are carried out to ensure that the produced products accomplish the desired outcomes. According to Fatmawati (2016),

researchers can use the validation's suggestions to improve learning tools for use in limited trials. The validated module meets the valid criteria, so it can be concluded that the comic is suitable for use in education, based on the validation analysis's findings.

b. Practicality of Comic-Based Modules

According to (Rahmayanti et al., 2016) validation is carried out based on the validator's assessment using a validation sheet provided by the researcher containing several aspects to be assessed. The evaluation results provided by material and media specialists serve as the basis for the information that this study gathered regarding the validity of the module. The physics teacher's response demonstrates the product's practicality. The teacher received a response score of 0.95, placing 95% of the responses in the "Good" category. The module's practicality was discovered by the student and teacher responses to the research questionnaire (Suastika & Rahmawati, 2019). The content, presentation, attractiveness, and usefulness of the module are all taken into consideration in this student response survey. The purpose of the teacher response survey is to determine how useful the module is for learning. In this research, the module is considered practical if both the teacher's and student's responses to the questionnaires meet the minimum "good" criteria.

c. The Effectiveness of Comic-Based Modules

According to Syubhan (2016), the effectiveness of the module is obtained from information on student learning test results.

CONCLUSION

Based on the opinions of physics teachers and

students as module users, it can be concluded that the comics developed on vibration and wave materials are suitable for use as learning modules. The comic-based physics module developed is useful and effective for improving students' critical thinking skills. Suggestions that can be made based on this research include adding sample questions with material explanations, developing modules according to student needs, and developing comic-based modules on other materials to arouse students' interest and make physics learning more interesting.

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