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WORD COUNT 5746 TIME SUBMITTED 12-MAR-2023 06:22PM

PAPER ID 97515769

JPSI 10(2):342-354, 2022
Jurnal Pendidikan Sains Indonesia
e-ISSN: 2615-840X p-ISSN: 2338-4379

Development of Electronic Modules Based on Critical Thinking Skills on Vibration, Waves, and Sound Materials for Junior High School Students

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DOI: 10.24815/jpsi.v10i2.23844

Article History: *Received: December 14, 2021* *Revised: February 17, 2022*
Accepted: March 11, 2022 *Published: March 26, 2022*

Abstract. Electronic learning resources are needed in accordance with the demands of basic competencies in learning and can be used by teachers and students as a means of independent learning at home or at school. This study aims to develop an electronic module on the material of vibration, waves and sound that is valid and practical. The Rowntree model used consists of three stages, namely planning, development and evaluation stages. At the evaluation stage, the researcher used the Tessmer evaluation stage, which consisted of the self-evaluation, expert review, one-to-one evaluation, and small group evaluation stages. The research subjects were students of class VIII.2 SMP N 1 Prabumulih. Determination of the sample one-to-one evaluation, selected three students. The three students consisted of one student with high, medium, and below medium abilities. Meanwhile, in the small group evaluation stage, it was tested in small groups consisting of several students consisting of 9 students who were selected based on different levels of ability. The research instrument used was observation, student needs questionnaire, expert validation questionnaire and student perception questionnaire. The data analysis technique used walkthrough and questionnaire methods. The resulting product is an electronic module of vibration, wave and sound material using the Flip PDF Professional program. The results of the research show: 1) the development of an electronic module based on critical thinking skills has been carried out through a development procedure that includes 3 stages. 2) the acquisition of the research results obtained content validation of 4.50 (strong valid), content validation of critical thinking skills of 4.61 (strong valid), design validation of 4.72 (strong valid), and language validation of 4 .50 (strong valid). So, the total average of the results of the content validation assessment, the content of critical thinking skills, design, and language is 4.60 including the "strong valid" category. 3) To produce a practical electronic module with research results, the average results of the assessment of student responses in the one-to-one evaluation stage is 4.55 and the average results of the assessment of student responses in the questionnaire are the small group evaluation stage is 4.60 with the "Extremely useful" category. The electronic module based on critical thinking on vibration, waves and sound material that has been developed is suitable for use as teaching material for class VIII junior high school students.

Keywords: Teachers, Students, Valid, Practical

Introduction

It can be seen by OECD 2019 which mentions that PISA 2018 result, Indonesia's position is ranked 7th from below. The 2018 PISA survey assessed 600,000 15-year-old students from 79 countries. Based on the survey, it was found that the mathematics ability score of Indonesian students was 379, ranked 7th from the bottom, while the average OECD member country for mathematics and science was 489 (Schleicher, 2019).

Developments in the field of science and technology in the 21st century have had consequences on the magnitude of the challenges different from those that have been faced before (Nahdi, 2019). The role of education through innovation or educational revolution is highly expected to prepare for the creation of a golden generation that can compete in the life of the 21st century. Critical thinking skills are an important aspect of learning and must be developed in facing the challenges of the 21st century (Astalini, et al., 2021; Zulkarnain, 2019). These skills include skills in accessing, analyzing, and synthesizing data (Hidayah, et al., 2017; Pratiwi, et al., 2021). So it is necessary to use technology in the process of developing learning media for natural sciences (IPA). Science is characterized by systematic and structured knowledge by connecting natural phenomena that are material and based on observations and inductions (Linda, et al., 2021). Physics is part of science, which was born and grew through a scientific process, the process includes observation, problem formulation, formulating hypotheses, testing hypotheses through experiments, drawing conclusions, and finding theories and concepts (Nabayra, 2020; Nurhadi, 2019). The learning process emphasizes providing direct experience to develop competencies in order to explore and understand the natural surroundings scientifically (Ernawita & Safitri, 2018; Nugroho & Zulfiani, 2021).

The use of technology by science teachers is expected to produce quality human resources so that science teachers can carry out creative and innovative learning. The learning method used must be able to hone the critical thinking skills of science teachers. In addition, the world is currently experiencing a disaster, namely the covid-19 pandemic, until September 2021, the pandemic has caused more than 31,972,560 positive cases and 1,074,023 deaths reported in 215 countries worldwide. The transition to online learning methods forces science teachers to follow a path that can be used so that learning can take place(Heliawati, et al., 2021; Septi, et al., 2019). Thus, Information and Communication Technology supports the development of learning materials that can be utilized in various pandemic conditions. Meanwhile, based on needs analysis obtained through interviews with teachers and questionnaires distributed to students randomly, it was found that science teachers and junior high school students still had difficulty finding electronic learning resources during the pandemic (covid-19) mass. The results consistently state students need practical electronic learning resources to be used anywhere and anytime, especially during a pandemic.

The results of the needs analysis above show that science teachers need to develop electronic teaching materials (modules). One ofOne of the teaching materials that we can and have developed is the electronic module. Electronic learning resources are needed in accordance with the demands of basic competencies in learning and can be used by teachers and students as a means of independent learning at home or at school. The electronic module is a solution that can present material with a combination of media such as audio, text, images and video (Hamid, et al., 2017; Karlina, et al., 2021). Not only that, the electronic module can be opened and read both through personal computers and smart phones with the required applications(Astalini et al., 2021; Tazkiyah et al., 2020). One application that can be used to compile electronic modules is Flip PDF Professional. Based on the results of the questionnaire, it was shown that the material for Vibration, Wave and Sound is quite difficult to learn. In this study we have developed an electronic module on the material of vibration, waves and sound based on critical thinking. Valid and practical electronic modules on wave and sound materials have been analyzed.

Methods

This development research will be carried out in the odd semester of the 2020/2021 academic year in several stages. This research was conducted at SMP Negeri 1 Prabumulih. The subjects in this study are the targets intended by researchers to study, namely (1) teaching materials in the form of electronic modules for vibration, wave and sound materials based on critical thinking skills; (2) students of SMP Negeri 1 Prabumulih as users of electronic modules.

The research model used in this research is the Rowntree model which consists of 3 stages, namely: (1) planning stage; (2) development stage; and (3) evaluation stage. At the evaluation stage, using Tessmer's formative evaluation model which consists of 5 stages, namely: (1) self evaluation; (2) expert review; (3) one-to-one evaluation; (4) small group evaluation; and (5) field tests. However, this research was limited only to the small group evaluation stage because the research did not see the effectiveness of the teaching materials developed.

Determination of the sample one-to-one evaluation, selected three students. The three students consisted of one student with high, medium, and below medium abilities. Meanwhile, in the small group evaluation stage, it was tested on small groups consisting of several students consisting of 9 students who were selected based on different levels of ability.

There are two data collection and analysis techniques used, namely, walkthrough data analysis techniques and questionnaire data analysis techniques. The results of the walkthrough according to the expert review were analyzed descriptively as input for revising the electronic module. Enter it written in the validation sheet. Questionnaire sheets in the form of validation sheets given to experts are made on a Likert scale. After that, questionnaire data analysis techniques. The questionnaire data collection technique is carried out at the one-to-one evaluation stage and the small group evaluation stage which aims to collect data in the form of responses, comments and suggestions from students which will then be used as a reference in revising the product (electronic module) (Sugiyono, 2016).

Walkthrough analysis was conducted to determine the validity of the developed product. The tool used to collect data is in the form of a questionnaire sheet given to the expert. The expert validation results obtained are adjusted according to the category. In addition to processing data from the assessment results by the validator, data is obtained in the form of suggestions and comments from the validator on the electronic module which then becomes input and reference in revising the electronic module to produce an electronic module that is feasible to be tested. This questionnaire data analysis was carried out to refine or revise the electronic module based on the responses from students. The results of the student questionnaires obtained were adjusted to the category. At this stage, suggestions and comments from students are also obtained which are written in the questionnaire sheet. These suggestions serve as input for improving the electronic module so that it becomes more feasible and easier to use.

Furthermore, the average value obtained based on data analysis with the average value equation will be confirmed to determine the level of validity and practicality of the vibration, wave and sound electronic modules that are being developed using the validity and practicality criteria as in Table 1 and Table 2.

Table 1. Category Validity Level

Average Score ($\overline{X}$)	Category
$4{,}2 < \bar{X} \leq 5{,}0$	Strong valid
$3{,}4 < \bar{X} \leq 4{,}2$	Valid
$2{,}6 < \bar{X} \leq 3{,}4$	Enough
$1{,}8 < \bar{X} \leq 2{,}6$	Not enough
$1{,}0 < \bar{X} \leq 1{,}8$	Very less

(Source: Widoyoko, 2018)

Table 2. Categories of Practicality Level

Average Score ($\overline{X}$)	Category
$4{,}2 < \bar{X} \leq 5{,}0$	Strong valid
$3{,}4 < \bar{X} \leq 4{,}2$	Valid
$2{,}6 < \bar{X} \leq 3{,}4$	Enough
$1{,}8 < \bar{X} \leq 2{,}6$	Not enough
$1{,}0 < \bar{X} \leq 1{,}8$	Very less

(Source: Widoyoko, 2018)

Results and Discussion

Development of electronic modules using the flip pdf corporate edition application. The application is not only glued to writing but can include moving animations, audio and learning videos. The corporate edition PDF flip application has more advantages(Munzil, et al., 2022; Shovrotul Khoiriyah, et al., 2020). The electronic module learning media is made with Flip PDF corporate edition software, this software is open source and the software can make a book display into an electronic book in the form of a flipbook (Andani, 2020; Jafnihirda, et al., 2019; Permana, et al., 2021). Figure 1 shows the electronics that have been successfully developed. In the planning stage, researchers conducted needs analysis and formulation of learning objectives. Needs analysis is done by giving questionnaires which are distributed to students and teachers. Based on the results of the questionnaire given, the school has implemented science learning according to the 2013 curriculum. But teachers have not applied critical thinking skills to teaching materials. The module used by students is still in the form of a printed module and students want a practical teaching material in the form of an electronic model. This is as ever done by Ghaliyah, et al., (2015) in the development of electronic modules and Maiyena & Imamora, (2020)in the development of electronic modules. Based on the syllabus determined by the Minister of Education and Culture, the materials for vibration, waves and sound are suitable to be developed into practical teaching materials by applying critical thinking skills in accordance with 21st century skills. Before designing the electronic module, the researcher formulated indicators and learning objectives for the material for vibration, waves and sound.(Marisda, 2016) of core competencies and basic competencies that refer to the 2013 curriculum.

Figure 1. Electronic module that has been designed.

The development stage, carried out several stages, namely topic development, drafting and prototype production. Topic development is carried out to determine the topics to be developed with the learning objectives to be achieved by students, then the preparation of an outline of the contents of the electronic module (GBIME) from the electronic module material vibration, waves and sound. After that, it was continued with drafting the contents of the electronic module, designing product components, determining

the software to be used, and finally producing prototypes. This stage aims to produce prototype I and compile an assessment instrument on the validation sheet and questionnaire sheet. In the evaluation stage, a tessmer evaluation was applied which consisted of four stages, namely (1) self evaluation, (2) expert review, (3) one-to-one evaluation, and (4) small group evaluation. Prototype I was carried out in a self-evaluation stage, at this stage a self-examination of the electronic module was carried out by examining the content of the material, the content of critical thinking skills, design and language to determine the accuracy and correctness that was developed. Electronic modules that are declared eligible will proceed to the expert review stage. In the expert review stage, the electronic module is then evaluated and validated by experts. The validation of this electronic module is focused on the criteria of content validity, language validity, design validity and critical thinking skills validity. In addition to providing expert validation assessments, they were also asked for feedback and suggestions that would be used to repair electronic modules for vibration, wave and sound materials. At this stage a self-examination of the electronic module is carried out by examining the content of the material, the content of critical thinking skills, design and language to determine the accuracy and correctness that is developed. Electronic modules that are declared eligible will proceed to the expert review stage. In the expert review stage, the electronic module is then evaluated and validated by experts. The validation of this electronic module is focused on the criteria of content validity, language validity, design validity and critical thinking skills validity. In addition to providing expert validation assessments, they were also asked for feedback and suggestions that would be used to repair electronic modules for vibration, wave and sound materials. At this stage a self-examination of the electronic module is carried out by examining the content of the material, the content of critical thinking skills, design and language to determine the accuracy and correctness that is developed. Electronic modules that are declared eligible will proceed to the expert review stage. In the expert review stage, the electronic module is then evaluated and validated by experts. The validation of this electronic module is focused on the criteria of content validity, language validity, design validity and critical thinking skills validity. In addition to providing expert validation assessments, they were also asked for feedback and suggestions that would be used to repair electronic modules for vibration, wave and sound materials. design and language to determine the accuracy and correctness developed. Electronic modules that are declared eligible will proceed to the expert review stage. In the expert review stage, the electronic module is then evaluated and validated by experts. The validation of this electronic module is focused on the criteria of content validity, language validity, design validity and critical thinking skills validity. In addition to providing expert validation assessments, they were also asked for feedback and suggestions that would be used to repair electronic modules for vibration, wave and sound materials. design and language to determine the accuracy and correctness developed. Electronic modules that are declared eligible will proceed to the expert review stage. In the expert review stage, the electronic module is then evaluated and validated by experts. The validation of this electronic module is focused on the criteria of content validity, language validity, design validity and critical thinking skills validity. In addition to providing expert validation assessments, they were also asked for feedback and suggestions that would be used to repair electronic modules for vibration, wave and sound materials. design validity and critical thinking skills. In addition to providing expert validation assessments, they were

also asked for feedback and suggestions that would be used to repair electronic modules for vibration, wave and sound materials. design validity and critical thinking skills. In addition to providing expert validation assessments, they were also asked for feedback and suggestions that would be used to repair electronic modules for vibration, wave and sound materials.

Module validation in *expert review* carried out by 3 experts, namely a master lecturer in physics education at Sriwijaya University and a science teacher at Prabumulih City Junior High School. *Expert review*produce qualitative data and quantitative data. Responses and suggestions from experts are qualitative data, while the average of the results of expert research to determine the level of validity of electronic modules for vibration, wave and sound materials is quantitative data (Andani, 2020). Results *expert review* by experts on the aspect of content feasibility can be seen in the following Table 3.

Table 3. Results of Content Validation Assessment

No	Indicator	Statement Number	Value Recapitulation	Value Category
1.	The suitability of the material with basic competencies and learning objectives	1.2	4.5	Strong valid
2.	Subject matter accuracy	3.4	4.5	Strong valid
3.	Up-to-date subject matter	5,6,7,8	4.5	Strong valid
4.	Benefits to add insight	9,10,11	4.5	Strong valid
	Average		**4.5**	**Strong valid**

The next research stage is an assessment of the validation of critical thinking skills aspects in electronic modules based on critical thinking skills on vibration, waves, and sound materials (Wati & Sudarma, 2020). The results of the validation assessment of critical thinking skills in the electronic module of the validator can be seen in the following Table 4.

Table 4. Results of the Validation of Critical Thinking Skills

No	Indicator	Statement Number	Value Recapitulation	Value Category
1.	Provide basic explanation	1,2,3	4.5	Strong valid
2.	Building basic skills	4.5	4.5	Strong valid
3.	Conclude	6,7,8	4.8	Strong valid
4.	Make further explanation	9.10	4.75	Strong valid
5.	Strategy and tactics	11.12	4.5	Strong valid
	Average		**4.61**	**Strong valid**

The next research stage is the validation assessment on the design aspects of electronic modules based on critical thinking skills on vibration, waves, and sound materials (Artiniasih, et al., 2019). The results of the validation assessment on the design aspects of the electronic module of the validator can be seen in the following Table 5.

Table 5. Design Validation Assessment Results

No	Indicator	Statement Number	Value Recapitulation	Value Category
1	Order of serving	1	4.5	Strong valid
2	Cover design and content of teaching materials	2.3	4.5	Strong valid
3	Use of fonts (type and size)	4.5	5.0	Strong valid
4	Illustrations, graphics and pictures	6.7	5.0	Strong valid
5	*lay out* (layout)	8.9	4.5	Strong valid
6	Complete information	10,11,12	4.83	Strong valid
	Average		**4.72**	**Strong valid**

Research on the validation of the linguistic aspects of the electronic module based on critical thinking skills on vibration, waves, and sound materials (Seruni et al., 2019). The results of the evaluation of the electronic module language validation based on critical thinking skills on the material of vibration, waves, and sounds from the validator can be seen in the following Table 6.

Table 6. Results of Language Validation Assessment

No	Indicator	Statement Number	Value Recapitulation	Value Category
1	Legibility	1.2	4.5	Strong valid
2	Information clarity	3.4	4.5	Strong valid
3	Conformity with good and correct Indonesian language rules.	5.6	4.5	Strong valid
4	Effective use of language.	7.8	4.5	Strong valid
	Average		**4.5**	**Strong valid**

Based on Tables 3,4,5 and 6, the average assessment results obtained from the four aspects, namely the content of critical thinking skills, content, design, and prototype language 1 electronic module based on critical thinking skills on the material of vibration, waves, and sounds are shown in the following Table 7.

Table 7. Average Total Expert Validation Assessment of Electronic Modules on Vibration, Waves and Sound Materials

No.	Electronic Module Validation	Mark
1	Content Validation	4.50
2	Language Validation	4.50
3	Design Validation	4.72
4	Critical Thinking Skill Validation	4.61
	Average	**4.60**
	Category	**Strong valid**

Based on the data recapitulation from the expert review above, it can be concluded that the electronic module of vibration, wave and sound material being developed meets the strong valid criteria. This is in line with the results of research conducted by (Nikita, et al., 2018). In addition, the suggestions from the three experts were all accepted and revised by the researchers in accordance with the suggestions given. After the revision is done, the evaluation continues with the one-to-one evaluation stage (Fahlia, et al., 2019). After the electronic module is declared valid at the expert review stage, it then enters the one-to-one evaluation stage. This one-to-one evaluation stage aims to see the level of practicality of electronic modules based on critical thinking skills in vibration, waves and sound materials that have been made by researchers. At this stage, prototype 1 electronic module was tested on 3 class XI students from SMP N 1 Prabumulih who had studied vibration, waves and sound. This evaluation aims to determine the practicality of the electronic module from the user perspective, identify and reduce errors overall.

The implementation of one-to-one evaluation is done by giving time for students to use the prototype of an electronic module based on critical thinking skills. Furthermore, students are asked to fill out a questionnaire to find out their responses to the electronic module that has been used. The results of the student response questionnaire assessment can be seen in the following Table 8.

Table 8. Recapitulation of the Results of the One-to-One Evaluation Stage

No	Indicator	Statement Number	Value Recapitulation	Value Category
1	Theory	1,2,3,4,5	4.4	Extremely useful
2	Giving Motivation	6,7,8	4.70	Extremely useful
3	Language	9.10	4.5	Extremely useful
4	Design	11,12,13,14,15,16,17	4.70	Extremely useful
Total			**4.55**	**Extremely useful**

In addition, students also provide suggestions and comments on the electronic module that has been developed to revise prototype 1. Some of the comments and suggestions of students on the electronic module that has been developed have been revised. Based on the revision results at the expert review stage and one-to-one evaluation of the prototype 1 electronic module, a prototype 2 electronic module was produced which was strong valid and Extremely useful which would then be tested at the small group evaluation stage.

The revised prototype based on expert judgment and student responses was then retested at the small group evaluation stage. The small group evaluation stage is the final evaluation stage of this research. At this stage, prototypes of 2 electronic modules based on critical thinking skills in vibration, waves and sound were tested on 9 students who were divided into 3 groups. Each group of students is welcome to read, study, or discuss the contents of prototype 2 with the direction of the researcher. At the end of the lesson, students were asked to fill out a questionnaire on their responses to the prototype 2. The results of the student response questionnaire assessment can be seen in the following Table 9.

Table 9. Recapitulation of Assessment Results for the Small Group Evaluation Stage

No	Indicator	Statement Number	Value Recapitulation	Value Category
1	Theory	1,2,3,4,5	4.50	Extremely useful
2	Giving Motivation	6,7,8	4.63	Extremely useful
3	Language	9.10	4.61	Extremely useful
4	Design	11,12,13,14,15,16,17	4.60	Extremely useful
Total			**4.60**	**Extremely useful**

Based on the data recapitulation from the small group evaluation that has been described in the table above, the researcher can conclude that the electronic module of vibration, wave and sound material developed by the researcher meets the Extremely useful criteria. This is in line with research (Septi, et al., 2019; Susanti, et al., 2020). Students also provide comments and suggestions for improving prototype 2. In general, students give positive comments on prototype 2 electronic modules. The majority of students' comments and suggestions that the electronic module based on critical thinking skills on vibration, waves and sound materials are very interesting and easy to understand. Based on the results of this study, the electronic module of vibration, wave and sound material developed by the researcher has good and proper quality, in line with the research (Febrianti, et al., 2017; Solihudin, 2018; Sriwahyuni, et al., 2019), so that the electronic module developed can be used as a means of learning science at school and at home.

Conclusion

The product in the form of a flip book e-module based on critical thinking skills has been successfully developed in which the content validation assessment is 4.50 (strong valid), the average result of the content validation assessment of critical thinking skills is 4.61 (strong valid), the average is 4.61 (strong valid). The average design validation assessment result is 4.72 (strong valid), and the average language validation assessment result is 4.50 (strong valid). So, the average total result of content validation assessment, the content of critical thinking skills, design, and language is 4.60, including the strong valid category. To produce an electronic module based on critical thinking skills practical material for vibrations, waves and sound with research results obtained the average results of the assessment of student responses at the one-to-one evaluation was 4.55 in the Extremely useful category and the small group evaluation stage was 4.60 in the Extremely useful category.

Acknowledgement

This research was financially supported by Sriwijaya University, Republic of Indonesia, through the University Leading Research Grant (PUPT) for the 2020–2021 fiscal year.

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