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DEVELOPMENT OF STEM EDUCATION INTEGRATED SOUND AND LIGHT WAVES E-MODULE FOR CRITICAL AND CREATIVE THINKING SKILLS

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ABSTRACT

21st-century education is an education described by the utilization of computerized innovation in the educational experience to further develop student's critical and creative thinking skills. The integrated teaching module of STEM education is still low, this is obtained from the analysis of STEM integration in textbooks, which is 57.89. The answer for defeat these issues is to foster a coordinated sound wave and light wave e-module in STEM schooling. This study aims to reveal the validity of the integrated sound wave and light wave e-module in STEM education. This type of research is included in research and development. This study uses the ADDIE development model. The instrument in this study used a content validity sheet. Technical analysis of the data in this study using Aiken's V. In view of the outcomes of the analysis of Aiken's V obtained a value of 0.83. Product validity is interpreted as a high validity category because the score is 0.8. In view of the aftereffects of this review, it was inferred that the e-module of sound waves and light waves integrated with STEM education was in the valid category and could be used in learning in schools on aspects of material substance, visual communication display, instructional design, software usage, and STEM assessment. Researchers hope that this e-module can be a reference for technology-based learning resources to create meaningful learning to encourage the improvement of high school students critical and creative thinking skills.

Keywords :*E-module,STEM education; critical and creative thinking skills*

I. INTRODUCTION

Indonesia has entered a new artificial period marked by the period of digitalization in various sectors of life. Experts call this the period of the artificial revolution4.0 [1]. Counterfeit revolution4.0 is a condition in the 21st century when gigantic changes do in different fields through a mix of advances that lessen walls between the physical, computerized and normal universes [2]. Artificial revolution4.0 encourages and forces the world encyclopedically to always acclimatize to the pendulum of change that moves so stoutly and snappily from time to time.

The 21st century can be said to be the century of knowledge. The 21st century is marked by a massive metamorphosis from an agricultural society to an artificial and sustainable society to a knowledge society. The 21st century is known as the period of knowledge, in this period, all indispensable sweats to meet the requirements of life in various knowledge- grounded surrounds [3]. The extraordinary acceleration of adding knowledge demands that 21st-century learning must be suitable to prepare the mortal generation to drink advances in information and communication technology in social life. The needs of the 21st century once in a while plead to impenetrable depths knowledge (cognitive) skills [4]. The demands of 21st- century work also bear workers to have various chops similar to creative thinking, problem- working, and communication. students who want to

contend in the global period must have the capability to communicate, unite, suppose critically, and be creative or known as 4C [5].

The revolution 4.0 empowers the mix of print and computerized innovation in the educational experience. different distributed learning media, one of which modules can be changed over into electronic structure, in this manner bringing forth the term electronic module or what's known as e-module [6]. E-modules or electronics are modules in a digital form conforming to textbooks, images, or both containing digital electronic material accompanied by simulation material that can and is doable to use in learning [7]. Electronic modules (e-modules) are the development of print modules in digital form. Electronic tutoring accoutrements can give openings for students to study learning accoutrements in their separate homes [8]. The advantages ofe-modules over print modules are that they're interactive, make navigation easier, allow displaying lading of images, audio, videotape, and vitality, and are equipped with constructive tests quizzes that allow immediate automatic feedback. One program that can be used to produce electronic tutoring accouterments in the form of e-modules is Flip PDF Professional [9].

Flip PDF Professional is software for creating digital books in the form of flipbooks. Flip PDF Professional is different from other pdfs. This operation can combine the material in the form of pdf lines with images, robustness, and learning vids that are still infrequently used in conventional learning [10]. software Flip PDF Professional needs to be used to train wisdom process chops [11]. The Flip PDF Professional operation has numerous advantages, videlicet, it's easy to use because it can be operated by newcomers who don't know the HTLM programming language. Flip PDF Professional has a point that functions to edit runners. This operation can produce interactive book runners [12].

Development and invention in the field of education have developed a lot, this is indicated by the number of new operations or software in digital form in the form of robustness, simulations, and electronic modules [13]. Along with the rapid-fire increase in technology, sweats can be made by preceptors to ameliorate 21st- century chops and balance the world of education in the ultramodern period, one of which is through STEM [14]. Learning with STEM (Science, technology, engineering, and mathematics) is known as multi-disciplinary learning in which the generalities of the material tutored will be acclimated and also combined with life in the real world. STEM is anticipated to be suitable to reduce the burden on students in dealing with problems in the real world by applying generalities related to various [15]. Other studies have also shown that STEM learning is able of forming interest [16].

Education in the 21st century remains closely connected with the utilization of computerized innovation and 21st-century learning hacks. 21st-century schooling is expected to be reasonable to deliver understudies who have a personal satisfaction as people who are imaginative, inventive, savvy, and broadly able. In addition, 21st- century learning is learner-centered, cooperative, connected to the real world, and has an environment and purpose [17]. 21st- century chops include creative thinking chops, critical thinking, problem working, communication, and collaboration [18]. Critical thinking chops are defined as a more complex form of thinking exertion, involving the analysis of further specific ideas as well as their development to be more perfect [19]. Creative thinking is the capability to associate various objects and knowledge with a result for a purpose [20]. The process of engineering in STEM learning is nearly related to 21st- century capacities. Research conducted by Musnidar [21] revealed that the STEM learning process can be carried out by integrating 21st- century chops. In addition, Khoiriyah [22] also revealed that STEM learning is excellent in advanced countries similar to the United States, Finland, Japan, Australia, and China which apropos educates students to be productive.

Based on this explanation, STEM education (*science, technology, engineering, and mathematics*) is interconnected in forming students who are more critical, creative, independent, and knowledgeable. Learning physics can be more meaningful when students can develop the experience gained from learning physics to understand the application of physics concepts related to using scientific principles and processes to make decisions. The combination of e-modules and STEM education will be able to balance the demands of industrial revolution 4.0, namely the demand for quality knowledge and skills, which are technology-based and by the demands of the times.

The reality on the ground does not describe the expected conditions. Based on preliminary studies that have been conducted at State High School 9 Padang. The first real condition was obtained from a questionnaire on two physics teachers. The results of the data analysis of the physics teacher's questionnaire responses obtained 53.68. This shows that the utilization of digital-based learning assets in the structure of e-modules is still low. The second condition is obtained from the analysis of STEM integration in textbooks. The results of the analysis show the value of 57, 32. This indicates that the integration of STEM in physics textbooks is still low. The third real condition was obtained from the research article. One of the physics materials that is considered quite difficult to

study is sound waves and light waves. According to research conducted by Istowati [23] that 16.67% of students feel that the material for sound and light waves is difficult to learn. These results indicate that it is still difficult for students to learn the material of sound and light waves. The last real condition is obtained from the performance assessment. The results of the data analysis showed that students' critical and creative thinking skills were 29.41 and 27.24. This shows that the critical and creative thinking skills of SMA Negeri 9 Padang students are still low.

The learning module has an important role in optimizing the teacher's function as a motivator, facilitator, and evaluator in learning. Technological developments encourage the combination of print modules with electronic technology. The presentation of the module can be transformed into electronic form so that it is given the term electronic module [24]. The use of electronic modules is one of the innovations in learning. Electronic modules are innovative media that can increase students' interest in learning [25]. The advantages of electronic media in learning make the educational experience really fascinating, intuitive should be possible whenever and anyplace, and can work on the nature of learning [26]. Ghaliyah ref[24] argues that the educational experience with electronic modules makes understudies as of now not subject to the teacher as the main wellspring of data, subsequently making intuitive and understudy focused learning. So that e-modules can provide independent learning experiences to students in solving problems in their way [27].

STEM schooling alludes to 21st-century learning. Krajcik and Delen [28] characterizes STEM as the amassing of information from different sciences, innovation, designing, and math as isolated however interrelated fields. STEM schooling urges understudies to be dynamic and talented in learning. Fikri [29] uncovered that STEM enjoys the benefit that it can coordinate the climate, innovation, and society since STEM educating coordinates content and abilities in acquiring. STEM training can urge understudies to configuration, create and use innovation, hone intellectually, control and emotional, and apply information [30]. STEM schooling straightforwardly frames talented understudies in improving reasoning abilities. This is upheld by the assessment of Pawilen [31] that STEM schooling includes understudies in their exercises to empower understudies to foster higher-request thinking abilities.

Two of the reasoning slashes required by 21st-century instruction are basic and innovative reasoning cleaves. Decisive reasoning is the scholarly discipline interaction of difficultly and skillfully conceptualizing, applying, integrating, as well as surveying data assembled from, or produced by, perception, experience, reflection, rationale, or correspondence as an ally for convictions and lead [32]. Decisive reasoning slashes are significant in light of the fact that they empower understudies to manage social, logical, and useful issues [33]. Basically, decisive reasoning can break issues really. Simply having information or data isn't sufficient. understudies should have an issue working slashes to make viable suppositions [34]. To assist understudies with creating decisive reasoning hacks, preceptors need to comprehend the cycles that comprise decisive reasoning and utilize instructive molding pointed toward fostering these cycles [35].

The alternate thinking skill is a creative thinking skill. According to Robinson [36], creative thinking is an important element in the development of wisdom and technology. Creative thinking is a habit of the mind that's trained by paying attention to suspicion, turning on the imagination, and revealing new possibilities. Creative thinking chops can be bettered through learning [37]. Creative students will generally ask further questions, answer a lot, have numerous creative ideas, have numerous ways to break problems, and know new expressions [38].

The use of e-modules in learning encourages provocation and interest so that students get an independent learning experience. Education that can encourage students to be active and professed in learning is STEM education. STEM education can help students hone the thinking chops demanded in 21st- century education. The integration of STEM in e-modules is anticipated to have a positive impact on students' thinking chops, especially critical and creative thinking chops. thus, an intertwined module of STEM education was developed to ameliorate students' critical and creative thinking chops.

The e-module utilized in this study was made utilizing Flip PDF Professional so that it's further pragmatic and alluring. The learning accouterments used in this e-module are in line with the drugs learning accouterments in the 2013 class. This e-module is also equipped with a worksheet as a companion for conducting virtual trials using virtual practicums to develop students' critical and creative thinking chops. Grounded on the background of the problem that has been described, the purpose of this study is to probe the validity of the integrated sound and light wave e-module in STEM education to ameliorate the critical and creative thinking chops of high academy students.

II. METHOD

The method used in this research is research and development methods. The R&D research method is a research method used to develop or validate products. The product developed in this research is an integrated sound and light wave e-module for STEM education to further develop the critical and creative thinking skills of high school students.

The development model in this study uses the ADDIE development model. This model was chosen because it describes a systematic approach to instructional development. The ADDIE model selected in this study was only up to the development stage. The ADDIE model consists of three stages, namely: 1) the analysis stage,2) the design stage, and 3) the development stage.

This research step consists of the analysis, design, and development stages. The analysis phase aims to investigate the problems faced by students in the learning process as well as the teaching materials needed in teaching and learning activities including teacher response questionnaire analysis, STEM integration analysis in textbooks, research articles, and performance assessments. Furthermore, at the design stage, the initial design of the e-module that will be developed is designed. The last stage of development consists of product creation and product assessment.

Product validation is carried out by three experts. Then the e-module is worked on after information and ideas from specialists.The instrument used in product validation is a validated validity sheet. The product validity assessment consists of five aspects, namely material substance, visual communication display, learning design, software usage, and STEM assessment.

Data analysis techniques in this study were analyzed descriptively and quantitatively depicted through tables and graphs. Descriptive analysis is used to find out detailed information from the validation data. Tables are used to provide concise and concise information related to the validity analysis on each aspect of the validation. Graphics are used to provide a visual impression of the level of validity of the integrated light and sound wave e-module for STEM education. The validation results were analyzed using Aiken's V calculations. The scoring by experts on the validation sheet uses a range of 1-4. The validity coefficient criteria which can be described in Table 1.

Table 1. Aiken's V Validity Coefficient Criteria [39]

Correlation Coefficient	InterpretationValidity
$V > 0.8$	High
$0.6 \leq V < 0.8$	Quite High
$0.4 \leq V < 0.6$	Enough
$0 \leq V < 0.4$	Poor

(Source: ref[39])

III. Results and Discussion

Results

a. Results in the Analysis Stage

Highanalyze problems that arise in the field. This analysis phase consists of an analysis of teacher responses to questionnaires, analysis of STEM integration in textbooks, research articles, and performance assessments. The first real condition was obtained from the analysis of the physics teacher's response questionnaire. The instrument used is a multiple choice questionnaire. Based on the data analysis, the results of the analysis were 53.68. This shows that the utilization of electronic modules at State High School 9 Padang is still low. Teachers still use the print module. The second real condition is obtained from the analysis of STEM integration in textbooks. The analysis of STEM integration in textbooks aims to determine the integration of STEM in textbooks used in learning Physics. The instrument used is a book analysis instrument. Based on the data analysis, the results of the analysis were 57.32. This shows that the integration of STEM in the physics textbooks used is still low.

The third real condition was obtained from the analysis of research articles. Research conducted by Istyowati ref [23] showed that 16.67% of students felt that the material for sound and light waves was difficult to learn. Physics material about sound waves and light waves because the wave material is abstract, students generally find it difficult to learn [40]. In addition, this material is also related to everyday life and the learning process carried out only discusses mathematical equations without interpreting the concepts of physics, especially in technology. The last real condition is obtained from the performance assessment. Performance assessment is carried out to see

students' critical and creative thinking skills. The instrument used is a performance assessment instrument consisting of critical and creative thinking indicators. Based on data analysis, it was found that students critical and creative thinking skills were 29.41 and 27.24. This shows that understudies' basic and innovative reasoning abilities as of now exist yet are still low and should be gotten to the next level.

b. Results in the Design Stage

The design stage is done to plan the item to be created. At the design stage, the experimenter designs the frame of the e-module to be developed. The product design made in the development of this exploration is an intertwined light and sound wave e-module for STEM education. Experimenters design learning objects that will be used as a reference for designing the e-module conception that will be developed. Experimenters take advantage of the shapes to point in Microsoft word in the product design process. Next, experimenters collect learning accouterments to be developed into products.

c. Results in the Development Stage

This stage is the durability of the design stage. The design that has been made is developed into a product. The product is also converted into a PDF and entered into the Flip PDF Professional. The process of fitting vids, robustness, and images into the product to make the product more interactive and intriguing. The e-module can be penetrated using the participated link. E-modules of sound swells and light swells can be penetrated using smartphones laptops PCs.

One element of the integrated sound wave and light wave e-module in STEM education is cover. The e-module cover contains data about the module material and the module personality. The front of this e-module is planned utilizing words. On the cover is depicted the e-module medications of sound grows and light grows coordinated STEM schooling, class XI, the name of the creator, and the University. The prevailing tones on the cover are blue, submarine, ultrasound, scanner, and beam as representations of the activity of sound grows and light enlarges. The front of the e-module should be visible in Figure 1.

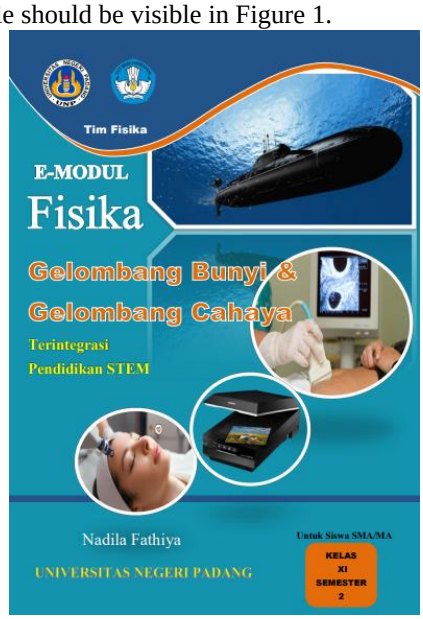

Figure 1. The cover of the Integrated Sound and Light Wave

E-Module in STEM Education The integrated light and sound wave module of STEM education developed formerly meets the norms for making tutoring modules. The integrated sound and light wave e-module of STEM education consist of a preface, table of contents, instructions for use, learning instructions, faculty achievements, learning objects, material descriptions, sample questions, conclusion worksheets, exercises, evaluations, and evaluation answer keys and a bibliography. The material introduced in the e-module is furnished with learning videos that assist understudies with figuring out the material. The worksheets in the e-module have integrated STEM education which encourages students' thinking chops. The STEM education integrated sound and light wave e-module contains exercises and evaluations that students can answer.

The e-module that has been developed is also validated by three validators to see the validity of the developed module. Before validating the e-module, the confirmation assessment instrument must first be validated. confirmation of the confirmation assessment instrument is useful to see whether the confirmation assessment instrument used to validate the e-module can measure the confirmation of the e-module or not. After validating the instrument, a valid order is attained, and the experimenter can validate the e-module. The confirmation carried out on the e-module includes aspects of the feasibility of the material substance, visual communication display, learning design, software operation, and STEM assessment. During the confirmation process, the validator provides suggestions and input on the designed product. Inputs and suggestions are veritably useful for experimenters to produce a sound wave and light wave e-module that's integrated into good and valid STEM education.

The first confirmation aspect is the substance of the material. The substance of the material has an assessment index conforming to verify, material content, current, and readability. The results of the confirmation of the material substance aspects that have been anatomized using the Aiken's V formula are presented in the form of Table 2.

Table 2. Analysis Results from *Aiken's V* on the Material Substance Aspects

Assessment Indicators	Many Points	Score *Aiken's V*	Coefficient *Aiken's*
Truth	4	0.94	High
Material Coverage	4	0.97	High
Current	3	0.74	Quite High
Readability	2	0.89	High
Average		0.89	High

Based on Table 2, the substance aspect of the material has an Aiken's V average of 0.89. The average aspect of the substance of the material is included in the high criteria. The material coverage indicator has the highest Aiken's V average of 0.97. Material coverage indicators include an assessment of the coverage of material in KD which is presented in full, STEM materials and activities can develop critical and creative thinking skills, there is a knowledge relationship between the four STEM aspects, and STEM materials and activities in e-modules can trigger students' imagination. Based on these indicators, it can be revealed that the accuracy of the material displayed on the e-module of sound waves and light waves integrated with STEM education is by physics material. So that the material coverage indicator has a high Aiken's V coefficient criterion compared to other assessment indicators based on the aspect of the substance of the material.

The alternate confirmation aspect is the visual communication display. Has assessment pointers including navigation, sources, media, colors, robustness, and layouts. The results of Aiken's V analysis on the visual communication display aspect are presented in Table 3.

Table 3. Analysis Results of *Aiken's V* on the Visual Communication Display Aspects

Assessment Indicators	Many Points	Score *Aiken's V*	Criteria *Aiken's*
Navigation	2	0.78	Quite High
Letter	1	0.89	High
Media	2	0.78	Quite High
Color	1	0.87	High
Animation	1	0.67	Quite High
Layout	1	0.67	Quite High
Average		0.74	Quite High

Based on Table 3, the visual communication display aspect has an average value of Aiken's V of 0.74. The average aspect of the visual communication display included in the criteria is quite high. The letter indicator has the highest Aiken's V average, which is 0.89. Based on these indicators, it can be revealed that the sound wave and light wave e-module integrated STEM education in the use of written fonts is appropriate. The color indicator describes that the sound wave and light wave e-module have an interesting color combination. Attractive color combinations can be an attraction and create enthusiasm for learning. Sound waves and light waves e-modules are equipped with pictures and sources, animations, Phet links, interactive evaluation buttons, and videos that support learning.

The third validation aspect is learning design. The learning design contains assessment indicators which include the title, KD, activity objectives, materials, sample questions, exercises, work steps, preparation, and references. The results of Aiken's V analysis on the learning design aspects are presented in Table 4.

Table 4. The results of Aiken's V analysis on the Learning Design Aspects

Assessment Indicators	Many Points	Score Aiken*'s V*	Criteria *Aiken's V*
Title	1	0.89	High
KD	1	0.89	High
Activity Objective	2	1.00	High
Material	1	0.89	High
Example Question	1	0.89	High
Exercise	1	1.00	High
Work Step	1	1.00	High
Preparation	1	1.00	High
Reference	1	1.00	High
Average		0.95	High

In Table 4 aspects of instructional design have an average Aiken's V value of 0.95. The average learning design component is included in the high criteria. The indicators of activity objectives, exercises, work steps, preparation, and references have the highest Aiken's V average of 1.00. Based on these indicators, it can be described that the sound wave and light wave e-module integrated with STEM education has to learn objectives that are by the indicators in KI & KD, the learning objectives in the e-module show the benefits for students, the exercises contained in the e-module have been by KD, the work steps contained in the e-module have been integrated into STEM education, and the references used in the e-module are sufficient. In the aspect of learning design, it is described that the e-module of sound waves and light waves has a good learning design for students. The material and examples of questions presented in the e-module of sound waves and light waves are by the learning objectives.

The fourth validation aspect is software usage. The aspect of the software usage consists of assessment indicators which include interactivity, supporting software, and originality. The results of Aiken's V analysis on aspects of software usage are presented in Table 5

Table 5. Analysis Results on Software Aspects Using

Assessment Indicators	Many Points	Score *Aiken's V*	Criteria *Aiken's V*
Interactivity	1	0.80	High
Supporting Software	3	0.89	High
Originality	1	0.67	Quite High
Average		0.79	Quite High

Based on Table 5 aspects of software users have an average value of Aiken's V of 0.79. The average aspect of the software usage included in the criteria is quite high. The supporting software indicator has the highest Aiken's V average of 0.89. Based on these indicators, it can be described that the e-module of sound waves and light waves integrated with STEM education already uses capable supporting software. In the software aspect, it was revealed that the sound wave and light wave e-module integrated with STEM education has created interactivity in questions and the learning process. The STEM education integrated sound and light wave e-module contains images, videos, and animations that are supported by sources.

The final validation aspect is the STEM assessment. Aspects of STEM assessment contain assessment indicators which include science, technology, engineering, and mathematics. The results of Aiken's V analysis on aspects of STEM assessment are presented in Table 6.

Table 6. Aiken's V Analysis Results on STEM Assessment Aspects Assessment

Indicators	Many Points	Score Aiken's V	Criteria *Aiken's V*
Science	2	0.78	Quite High
Technology	2	0.89	High

Engineering	2	0.67	Quite High
Mathematics	2	0.78	Quite High
Average		**0.78**	**Quite High**

Based on Table 6, the STEM assessment aspect has an average Aiken's V score of 0.78. The average score of Aiken's in the STEM assessment aspect included in the criteria is quite high. The technology indicator has the highest average Aiken's score of 0.89. Based on these indicators, it can be explained that the e-module of sound waves and light waves integrated with STEM education is equipped with examples of technology related to science and the application of technology in e-modules can trigger students' critical and creative thinking skills. In the STEM assessment aspect, it is described that the e-module of sound waves and light waves has presented the relationship between the material and the real situation of students correctly and is supported by experiments to increase students' knowledge, there is knowledge about the design and working principles of technology and can trigger the emergence of critical thinking skills. and creative students and contains the basic mathematics underlying product design.

The validation of the integrated sound and light wave e-module of STEM education has five aspects. These five aspects of validity are the feasibility of the substance of the material (SM), visual communication display (KV), learning design (DP), software usage (PL), and STEM assessment (PS). The results of the analysis of each aspect of validity can be explained in Figure 1.

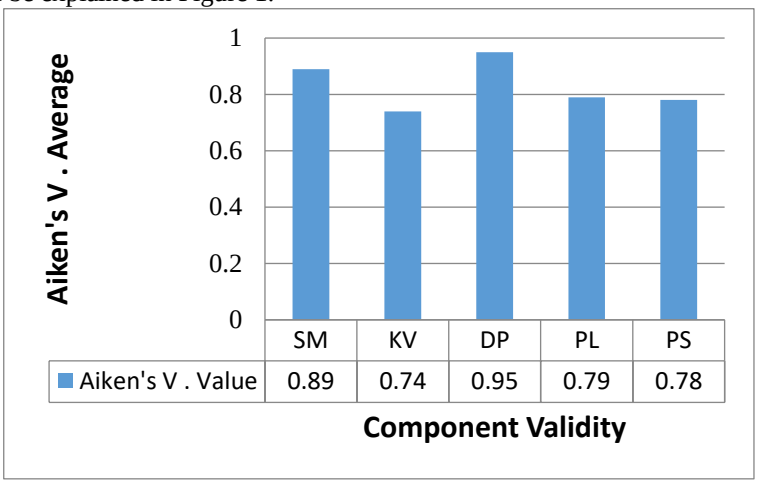

Figure 2. Graph of Validity Analysis Results

Based on Figure 2 it can be explained that the average validity of each aspect is in the valid category. The validation value of the visual communication display is 0.74 with a valid category. This means that the developed e-module is visually appealing to use. The value of learning design validation is 0.95 with a valid category. This shows that the learning design contained in the e-module is appropriate and has a good learning design. The value of using software validation is 0.79 with a valid category. This means that the developed e-module has good feedback from the system and has used several supporting software. And the value of the validation of the STEM assessment is 0.78 with a valid category. The average results of the analysis of the validity of the sound wave and light wave e-modules were obtained at 0.83. The criteria for the average value of the validation are included in the high criteria. This shows that the integration of STEM education into the integrated sound wave and light wave e-modules of STEM education to further develop students' critical and creative thinking skills is appropriate**.** In view of the consequences of the review it was presumed that The integrated sound wave and light wave e-module developed for STEM education is valid and can be used in learning.

Discussion

This research developed an e-module of sound waves and light waves integrated with STEM education to further develop students' critical and creative thinking skills. Before using the e-module, it must go through the validation stage first. The measurement or validation instrument in this e-module consists of 44 indicators which are divided into five aspects, namely the feasibility of the material substance, visual communication display, learning design, software usage, and STEM assessment. Data analysis on each aspect shows a valid category.

According to Azwar ref [39], a product is said to be valid if it has a category of 0.61. This is in line with research conducted by Syahiddah ref [13] that STEM-based e-modules are feasible to use in the learning process. Research conducted by Izzah [41] shows that STEM-based teaching materials will be more effective if they are carried out at the high school level with book teaching materials. In addition, a similar study conducted by Ritongga [42] showed that STEM schooling had the option to further develop decisive reasoning abilities. And research conducted by Kristen [43] also shows that STEM education can improve students' creative thinking skills. Researchers hope that the e-module of sound waves and light waves integrated with STEM education can be used in learning Physics as an innovative learning resource and this e-module of sound waves and light waves can create more meaningful Physics learning and encourage the improvement of critical thinking skills. and creative students.

Perfect research is something that is not easy to realize in the implementation of research. There are several limitations that the authors encountered in carrying out the research. The author hopes that the limitations contained in this study will be a consideration for future researchers in carrying out similar research. The first limitation is that the product developed is only up to the validation stage. This is due to the limited time of research in conducting research. Researchers hope that in further research the products that have been developed can be implemented in schools.

The second research limitation is the applied learning materials. The material used in the STEM integrated e-module is limited to sound and light waves only. The researcher hopes that in future research the material used in the integrated e-module of STEM education on students' critical and creative thinking skills can be developed in other learning materials.

The third limitation of the research is that 21st-century skills are measured only in terms of students' critical and creative thinking skills. 21st-century skills include creative thinking skills, critical thinking, communication, and collaboration. The researcher hopes that in future research, the integrated e-module of STEM education can also measure other 21st century skills, namely student communication and collaboration skills.

The constraint of the last exploration is the product utilized in the assembling of coordinated light and sound wave e-modules in STEM training. The product utilized in the improvement of this e-module is Flip PDF Professional. This product will deliver e-modules as flipbooks that use different media like sound, video, and glimmer. The scientist trusts that in future examination, the coordinated e-module of STEM training can be created with other programming.

IV. CONCLUSION

Based on results of the research, it can be said that the validity value of the STEM integrated sound wave and light wave e-module to improve students' critical and creative thinking skills is 0.83 which is included in the high category. It is valid in substance of the material, visual communication display, learning design, software usage, and STEM assessment so that it can be used in learning at school. The limitations of this research are only up to the validation stage, it is hoped that further research can implement the e-module developed in schools.

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