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Development of STEM-Based Modules on Wave Material for Class XI High School Students

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Abstract: The competency standards of class XI graduates in physics learning are deemed inadequate. One element contributing to this is the lack of physics modules based on learning methodologies to guide students' active learning. The goal of this research is to create a STEM-based module on Wave material that is practicable in class XI SMA. Research and development (R&D) utilizing the 4D model (define, design, develop, and disseminate) is employed. Validation sheets and limited trial sheets for students using a four-Likert scale were supplied to experts, teachers, and 30 students from SMA N 8 Mandau. The initial analysis of this research was carried out to determine the student's condition, and documentation was employed as evidence. The data were quantitatively assessed based on the outcomes of expert validation, teachers, and limited student trials. The validation using the average value performed by three expert validators or experts yielded a validation value of 0.81, while the score acquired from three user or teacher validators was 0.93, and the results of the limited trial of students yielded a validation value of 0.80. The results in the form of STEM-based modules on wave material in class XI SMA that match the criteria are high. Based on the results, the STEM-based curriculum is appropriate for use in class XI SMA.

Keywords: Develop; Module; STEM.

Introduction

Education in Indonesia is still of poor quality. Since Indonesia is an archipelago, achieving equal development is difficult. Because of uneven development, the quality of education varies by region in Indonesia (Friantini & Winata, 2021). One of the reform and improvements in educational performance that support one of them is curriculum. The curriculum is a set of plans and arrangements about the objectives, content, and learning resources, as well as procedures used as instructions for organizing learning activities (Nurlaeli, 2020).

The learning process is defined as the interaction between teachers and students that occurs in a learning scenario in order to attain learning goals (Istiyono, 2018). Teachers and students are inseparable parts of the system. The aspect of education that is closely related to the growth of the modern era is science education. Science education is a set of disciplines used to assess a country's educational progress (Zubaidah et al., 2017). Science education, as part of education, is critical to the development of the Indonesian nation's capacities. Science education seeks to stimulate people's interest and curiosity so that intelligence and understanding of nature as a whole can grow. Physics is one of the courses taught in science classes (Fakhruddin et al., 2021).

The variety of teaching methods employed by teachers has a significant impact on students' interest and motivation in the learning process. The variety of strategies used by the teacher influences the learning process significantly (Adawiyah, 2021). A good learning strategy will restore students' capacity to recall previously learned lessons (Pesona, 2022). Learners will be more motivated to perform at their best and learn faster if they are aware of their different learning styles (Dare et al., 2019).

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To understand the many pieces of information presented in each subject, language skills are required (Nabunome & Hastuti, 2018). Students' ability to learn connected physics formulas is heavily reliant on their memory and comprehension of the subject (Istiyono, 2018). Thus, media are needed that contain material 1 basic competence suitable for discussing material about Travelling Waves and Stationary Waves. The media used is a module as a significant teaching material in learning activities (Ramadhani & Fitria, 2021).

Modules are learning tools or means that contain material, methods, and limitations, that are written by educators, that are systematically designed and appealing to achieve the expected competencies based on their level of complexity, and that students can study independently (Puspitasari, 2019). Modules are defined as a collection of learning that is organized and used to help students attain learning objectives (Ramadhani & Fitria, 2021). As a result, the module will make it easier for students to meet their learning objectives (Anggraini et al., 2017).

The purpose of 21st century integrated learning is to prepare students from a young age to achieve superior, creative, innovative, and competitive achievements in the future. Science, Technology, Engineering, and Mathematics (STEM) originated as a method for integrating more than one subject that learners require in order to be creative (Kurup et al., 2019). Achieving success as the primary goal of the STEM approach requires collaboration among teachers, principals, curriculum managers, and student participation. Teachers are the most crucial persons in STEM implementation success (Dare et al., 2019; Hudha et al., 2019; Kurup et al., 2019). This is why it is important to know teachers' perspectives, particularly on how they incorporate STEM into their regular learning activities. As a result, teachers will be able to determine which STEM should be applied in formal schools (Karisan et al., 2019). It is a learner-centered approach with a focus on collaborative learning. This educational strategy associates and combines the disciplines of science, mathematics, technology, and engineering with the capabilities of these subjects. It has recently been at the heart of educational progress (Batdi et al., 2019). STEM applications can be found in all parts of life, not just education. However, there are six STEM application principles in formal primary and secondary education. These principles are based on the cognitive and psychomotor development of learners' ages.

Based on the background, it is necessary to develop a module that educators and students may use in the learning process. As a result, this study will develop a STEM-based module on wave material for grade XI high school students.

Method

The method used in this research is research and development (R&D) with the 4D model, which includes the steps of define, design, develop, and disseminate. This development research focused on the development of STEM-based modules on wave material for grade XI high school students. The 4D research procedure is shown in Figure 1.

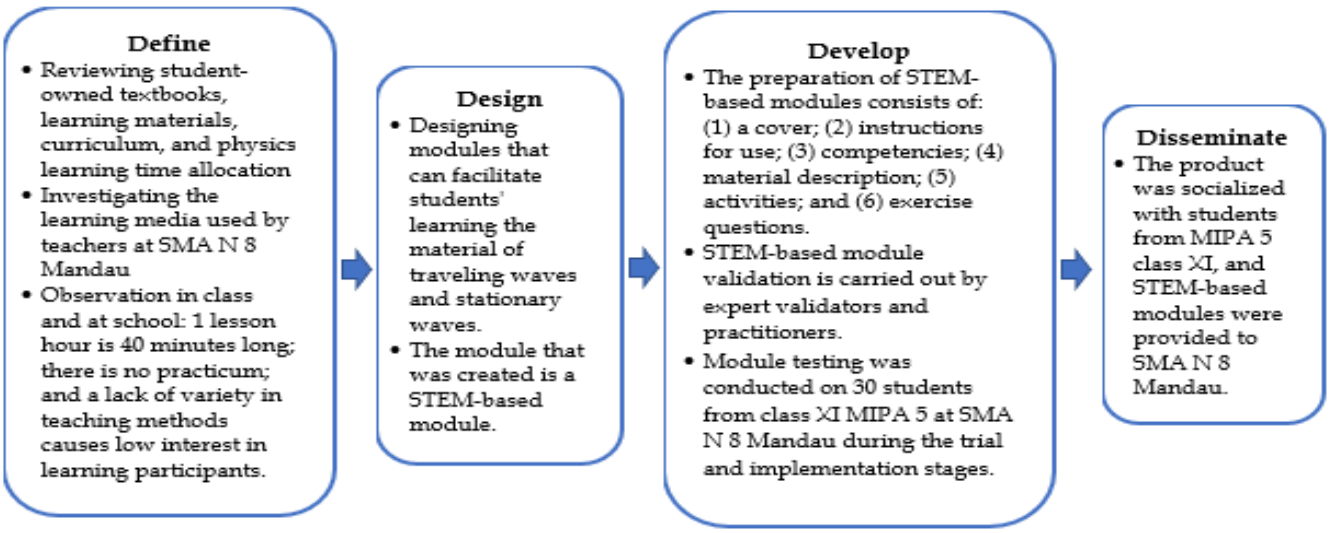

Figure 1. 4D Model Procedures and Research Instruments

The instrument was then validated using a validation sheet by considering several factors. This research was carried out at the senior high school in March 2023. This study developed a module that was

validated by experts and practitioners and was trialed on 30 students in class XI.

Data collection techniques consisted of module validation sheets. Prior to the investigation, observations were taken to assess the state of the school and the learning process. Documentation was completed in order to save research data. The validation results were averaged and categorized based on the viability of the developed STEM-based module. The data obtained from the validation and practicality sheets are expressed in the form of a Likert scale with four assessment criteria that state the level of agreement with the assessment items. Table 1 shows the Likert scale criteria that were used.

Table 1. Likert Scale Scoring Categories

Score	Categories
1	Strongly Disagree
2	Disagree
3	Agree
4	Strongly Agree

Source: (Sugiyono, 2015)

An assessment item is declared valid if all experts give it a score of at least 3. The draft module is declared valid overall if all items have been declared valid by all experts. The criteria for the validity of the draft module can be expressed by the overall average of the items. The learning instruments used in this study have been validated by experts as expert validators and teachers as practitioner validators. The results of the instrument validation score were analyzed using the V Aiken (Aiken, 1985). The steps to analyze it using Equation 1.

$$V = \frac{\sum(r_i - l_0)}{[n(c-1)]} \quad (1)$$

Tabel 2. Categories of V Aiken

Average of Interval Score	Categories
$V \leq 0.4$	Low
$0.4 < V \leq 0.8$	Medium
$0.8 < V \leq 1$	High

Sumber: (Dier & Asrizal, 2023; Kowsalya et al., 2012)

From the Equation 1 it can be explained that r is the value given by the validator, l_0 is the lowest number of validity assessments, n is the number of expert and practitioner validators, c is the highest number of validity assessments, and i is an integer from 1,2,3, to n. The value of the V Aiken index calculation of an item can be categorized based on its index into three categories, namely high, medium, and low. For the division of the index category V Aiken, as shown in Table 2. After obtaining the module validity value and being declared valid, the STEM-based module can be tested in small group trials.

Result and Discussion

A STEM-based module on wave material is for class XI, second semester. The developed STEM-based module was then tested with grade XI students. The STEM-based module on wave material presents activity sheets and exercises. In general, the activity sheet is used as a medium to support virtual experiment activities (virtual labs) in order to train students in technology and how to use virtual labs. The STEM-based module provides innovation in physics learning media because it trains students with the questions in it (Astuti et al., 2021). The STEM-based module display is presented in Figure 2. The results of validation by 3 expert validators, 3 practitioner validators (teachers), and limited trials by 30 students of STEM-based modules.

Figure 2. The STEM-based module display

Expert Validator

Before being used in the study, the module was evaluated for feasibility by three validators (Yulkifli et al., 2022). The average value was used to examine instrument validation scores, which were afterwards converted into validation criterion intervals. The STEM-based module assessment was based on aspects of appearance, learning, material, and language (Ibrahim et al., 2022). Before the STEM-based module was implemented in the limited trial class, the corrections given by the validators to the media were then revised. Table 3 displays the findings of validation by three expert validators for STEM-based modules.

The average validation of the STEM-based module received a score of 0.81 based on the evaluation of the three validators in Table 3. Based on the interval, the score is included in the high criteria, indicating that the STEM-based module developed is appropriate for use in the learning process of traveling and stationary waves.

Table 3. Results of STEM-Based Module Validation by Experts

Assessment Indicator	Mean V Aiken	Category
Appearance	0.82	High
Learning	0.78	Medium
Material	0.79	Medium
Language	0.83	High
Average	0.81	High

Practitioner Validators

Before being employed in the study, the module had been tested for feasibility by three practitioner validators (teachers) (Syarlisjiswan et al., 2021). Average scores were used to examine instrument validation scores, which were then converted into validation criteria intervals. The STEM-based module assessment was assessed based on the quality aspects of content, language, appearance, and usability. Before the STEM-based module was implemented in the limited trial class, the validators' correction to the media were then revise. Table 4 displays the results of three practitioner validators' validation of STEM-based modules.

Table 4. Results of STEM-Based Module Validation by Practitioners

Assessment Category	Mean V Aiken	Category
Content Quality	0.95	High
Language	0.89	High
Appearance	0.89	High
User	1.00	High
Average	0.93	High

The average validation of the STEM-based module received a score of 0.93 based on the evaluation of the three teacher validators in Table 4. Based on the interval, the score is included in the high criteria, indicating that the STEM-based module developed is appropriate for use in the learning process of traveling and stationary waves.

Limited Trial by 30 Learners of the STEM-Based Module

Thirty students from class XI participated in the limited trial. The average value was used to examine the limited trial scores Retnowati et al. (2020), which were then converted into validation criterion intervals. Students completed 17 statements, and STEM-based modules for students were evaluated based on presentation, language, graphics, and advantages. The results of the limited trial of the module were revised before implementing the STEM-based module in the operational trial class. Table 5 shows the results of a limited trial of 30 students for the STEM-based module.

Table 5. Results of Limited Trial of STEM-Based Module

Assessment Indicator	Mean V Aiken	Category
Presentation	0.81	High
Language	0.77	Medium
Graphics	0.80	High
Advantages	0.80	High
Average	0.80	High

Based on the results of the limited trial in Table 5, the average results of the limited trial of the STEM-based module obtained an average score of 0.80. Based on this interval, it shows that the score results are included in the "high" criteria. This shows that, according to students, the STEM-based module on traveling waves and stationary waves is very interesting.

Conclusion

Based on the module development research, it ican be concluded that a STEM-based module on wave material has been developed for grade XI high school students utilizing the 4D model (Define, Design, Develop, and Disseminate) and limited trials. STEM-based wave material modules in class XI have been categorized as feasible to use as teaching material. This is based on validation which states that the feasibility of the module by 3 expert validators in the high category gets a score of 0.81, the average value of 3 user/teacher validators is 0.93 and the results of limited trials with an average of 0.80. Students consider STEM-based modules easy to use and practical. Future researchers are advised to test STEM-based modules on other physics materials and see the difference in results. The research and development results revealed that the STEM-based module on wave material was deemed valid and feasible to use in a high category.

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The authors jointly cooperative to complete this article at each stage.

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Conflicts of Interest

The authors declare no conflict of interest.

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