Development of Physics Textbooks Based on STEM Integrated to Quranic Verses in Traveling and Standing Waves Subject

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Abstract: A Textbook is one of the learning tools that is commonly used by students. The purpose of this research is to describe the stages of developing a STEM-based textbook integrated with Quranic verses and to measure the effectiveness of the textbook to enhance students' conceptual understanding of traveling and standing waves and to acknowledge students' insight into spiritual knowledge. This research used a research and development method with a 4D model. The 4D model consist of four stages developing process. Those are to define, design, develop and disseminate. The research subject were the students of XI MIPA3 of MAN Pemalang as for experimental class, and students of XI MIPA 4 of MAN Pemalang as a control class. Based on expert judgements this STEM based textbook was categorized to a valid and acceptable textbook for use in learning process with an average score 77.4%. The effectiveness of the STEM based textbook integrated to Quranic verses to enhance conceptual understanding was measured with the pretest-posttest control group design. The result showed that the textbook is effective in improving students conceptual understanding of traveling and standing wave subject.

Introduction

Today, technologies and society have developed rapidly. This phenomenon also affects the education system. According to Rahayu (2022), the development of the educational system must be done to suit the 21st-century era. This development occurred in every aspect, such as curriculum, learning media, learning activities, and so on. 21st century learning has 4 main principles, the first is that students must be the main subject of the learning process. They need to be guided to actively participate to find meaningful learning and maximize their interest and skills themselves. Second, students need to be guided to collaborate with others in their class to get more meaningful information. Third, learning process use the contextual approach, give the student to experience outside classroom. Fourth, there is a role of school in facilitating learning activities outside school and carrying out activities within students' social environment (Yuliati and Saputra 2019).

STEM (Science, Technology, Engineering, and Mathematics) is a learning approach that is able to integrate several skills needed to prepare for the 21st century (Widayoko, 2020). Science, Technology, Engineering and Mathematics in the education system are considered to be one of the solutions to answer the challenges of 21st century learning. The STEM approach in education emerged as an answer to realizing that students are part of a social system (Kelly & Knowles, 2016). However, according to Mubarok *et al.* (2020), several social aspects of society are not included in STEM. These other aspects include art and religious aspect.

The study conducted by Billingsley *et al.* (2014) stated that although science teachers in England had difficulties in collaborating science and religion, religion has influenced their learning approaches on certain topics. The science aspect helps students to answer "how" questions about a phenomenon. As for technology, engineering and mathematics act as tools to provide solutions. Meanwhile, religious aspects play a role in answering the question "why" of a phenomenon, and explaining things outside of science.

Religion will give students richer epistemic insight in dealing with problems.

This research begins with problem analysis and needs analysis at MAN Pemalang. The analysis results show several obstacles that occur in physics learning in the classroom. These obstacles include limited textbooks, a lack of variety in the learning process, and limited use of learning media. The learning books used are in the form of modules containing short material. The learning process is carried out with lots of discussion of questions and focuses more on solving mathematical problems, so that students participate less actively in the learning process and do not emphasize understanding physics concepts. Therefore, it is necessary to develop learning media that can maximize the learning process so that it can maximize students' conceptual understanding in physics lessons.

According to case studies and the needs faced at MAN Pemalang, it was concluded to carry out the development research. The research is aimed to make a textbooks, especially for student learning materials. The textbook was developed using a STEM approach by integrating it with verses from the Quran and the facts contained in it. The novelty in this research lies in the STEM learning approach that is integrated with Quranic verses to answer problems that occur at MAN Pemalang. STEM is a learning approach that can integrate the skills needed by students to address the challenges of the current digital era (Widayoko, 2020).

Methods

This research is a development research that adopts the 4D model from Thiagarajan's, which consists of four stages, namely define, design, develop, and disseminate (Fitriyah, 2021). In this research, data analysis was conducted using both qualitative and quantitative approaches. To measure the validity of the textbook that has been developed, use the validation paper by the expert judges. The Suggestions and critiques from experts and students were analyzed using a qualitative approach, while the measurement of effectiveness was processed using a quantitative approach.

In this research, the steps of collecting data in school are using a pretest-posttest control design. The STEM-based textbook integrated with the Quran was implemented at MAN Pemalang. The research subjects are the class of XI MIPA 3 to be the experimental class, and the class of XI MIPA 4 as the control class. The effectiveness of the textbook implementation in the class of experiment is determined by calculating the score of normalized gain ($n\ gain$). It can be done with comparing the $n\ gain$ value of both experiment and control class. $n\ gain$ value can be done by Equation (1) and Equation (2).

$$N\ gain = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score} \qquad (1)$$

$$effectiveness = \frac{n\ gain\ of\ experimental\ class}{n\ gain\ of\ control\ class} \qquad (2)$$

And the effectiveness level is measured by using Equation 2. The textbook was categorized as effective if the result of Equation 2 is more than 1, and it's not effective if the result is less than 1.
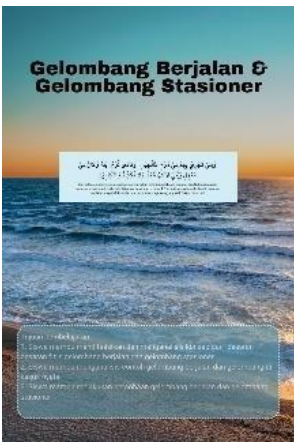
Results and Discussion

Based on the 4D stages conducted (define, design, develop, disseminate), the following results were obtained. First is the Define *Stage*. In this stage, the activities included problem analysis and needs analysis are carried out at MAN Pemalang. The result of the analysis shows that students have difficulty understanding and following physics lessons. Physics lessons are considered difficult and complicated. Apart from that, physics learning in class still uses the tech-centered method. The learning facilities used by students are textbooks or handbooks in the form of modules from schools, which are limited, so the students need to share the module with others for usage.

Second is the Design *Stage*. The design of the textbook includes the development of test criteria, media selection, format selection, and initial design. The design of the STEM-based textbook integrated with the Quran in the wave subject is divided into three main parts: introduction, content, and conclusion. The

textbook being developed has the general characteristics of being in the form of B5-sized print media, the subject is limited to traveling and standing waves, and it uses a STEM approach integrated with the Quran. The textbook has 5 points of characteristics, presenting integrated concepts, oriented towards the application of traveling and standing waves in technology, oriented towards science and engineering processes, containing coherent mathematical explanations, and oriented towards character development in the form of religious insight by correlating science and the Quran.

Third is the Development Stage, where the researcher developed the textbook with the help of the MS Word and Canva applications. The textbook design developed includes cover, title, foreword, concept map, STEM page, and material content. The presentation of material content using an integrated STEM approach to the Quran is outlined in several features as shown in Table 1.

Table 1. Outline of the Textbook

Cover book	Learning aims	Map of concept
STEM Page	Science and mathematics concept	Coloumn of Tech

DID YOU KNOW? 🔍 Dalam QS. Az Zalzalah Allah menceritakan tentang dahsyatnya guncangan gelombang gempa saat hari kiamat. Menariknya pada ayat ke-4 terdapat pernyataan bahwa ketika gempa, bumi "mengabarkan beritanya" يَوْمَئِذٍ تُحَدِّثُ أَخْبَارَهَا – ٤ *Artinya: "Pada hari itu bumi menyampaikan beritanya".* *(QS. Az-Zalzalah Ayat 4)* Dan faktanya, Ahli Seismologi mendapatkan informasi informasi penting terkait bumi dari perambatan gelombang gempa. Model bumi berlapis hingga karaktristik masig-masing lapisan didapat dari penafsiran perbedaan cepat rambat gelombang di masing-masing lapisannya.	⚙️ **Insinyur Muda** ➤ A. Studi kasus Mia adalah siswa yang berasal dari daerah yang rawan gempa. Suatku kecil ia pernah merasakan gempa yang besar, dan didaerahnya sellau terjadi gempa bersekala kecil setiap hari. Beranjak SMA mia ingin memasang alat deteksi gempa dilingkungannya. Sebagai seorang insinyur bantulah merancang sebuah seismograf sedderhana untuk Mia. Untuk memulai perancangan, ambil gadgetmu dan pelajarilah video dengan membuka tautan berikut: https://www.youtube.com/watch?v=41RzGwZINOk&pp=ygUeaG93IHRvIG1ha2Ugc2Vpc21vZ3JhcGggbW9kZW wg atau	**Latihan** Kerjakan soal-soal berikut! 1. Ujung sebuah tali yang panjangnya 1 meter di getarkan sehingga dalam waktu 2 sekon terdapat 2 gelombang. tentukanlah persamaan gelombang tersebut apabila amplitudo getaran ujung tali 20 cm. 2. Persamaan gelombang transversal yang merambat pada suatu tali dinyatakan sebagai berikut. $y = 10 \sin 2\pi \ (\ 0,5 \ x - 2 \ t)$ Jika x dan y dalam meter, serta t dalam sekon, tentukanlah cepat rambat gelombang tersebut. 3. Gelombang tranversal merambat dengan frekuensi 500 dan kecepatan 300 m/s. Berapakah jarak antara dua titik yang berbeda sudut fase 60° ?
Adding features	Being Engineer	Questions

Each subchapter in this book begins with a Quranic verse describing wave phenomena. The stem component in this book is reflected in the content of each subchapter. The science component pertains to natural phenomena, encompassing knowledge from disciplines such as biology, physics, and chemistry, and enabling direct observation. In this textbook, students are invited to directly observe the phenomena of traveling and standing waves in the form of waves on a string and surface waves. In addition, students also observe and calculate such as the frequency and period of the waves that appear. In this process, students are directly involved in the process of concept discovery and mathematical understanding.

The technology component includes knowledge about technology, its applications, and its development. The technology component in this book is shown by the 'column of tech' content which explains the application of wave principles to seismographs, which are then integrated with the engineering components. The engineering component involves applying conceptual understanding, fostering innovation, and designing and creating products. The 'Being Engineer' content lets students work in groups to make a simple seismograph from simple materials. The mathematics component focuses on the ability to analyze, formulate, and interpret solutions to mathematical problems. This is demonstrated in each wave equation, along with example problems and solutions. All STEM components are presented in an integrated form, explaining the concepts of traveling and standing waves. Each subchapter in this book is also integrated with Quranic verses related to wave phenomena in nature, providing students with new information and enhancing their religious insight.

After the develop stage and before the fourth stage (dissemination), validation towards the textbook had been done by the expert. The aspects assessed in this validation process are aspects of content suitability, material suitability aspects, linguistic aspects, and graphic aspects. The assessment from each validator obtained the following results.

Table 2. Expert Judgement Towards STEM based Textbook Integrated with Quran

Aspects	Average score		Percentage average (%)
	Validator 1	**Validator 2**	
Content suitability	3.5	4.5	80
Material suitability with STEM approach integrated with Quran	3.6	4	76
Linguistic	3.75	4	77.5
Graphic	4	3.6	76

From the results of the expert validation assessment above, it shows that each aspect has its own feasibility value. The feasibility aspect of the material content received a score of 80%, which means that the

material aspect is very feasible. The aspect of suitability with the integrated STEM approach to the Quran obtained a score of 76%, which means it is included in the feasible category. Aspects of language use and drafting also meet the appropriate criteria with scores of 77.5% and 76%. From the results of this assessment, it can be concluded that the STEM-based textbook integrated with the Koran in wave material is valid and suitable for use in learning with an average feasibility percentage of 77.3%.

As for the effectiveness from STEM based textbook integrated with Quran is measured by the result of pretest and posttest score as shown in Table 3. Pretest-posttest control group design are well suited to investigation effects of educational innovations and are common in educational research (Dugard and Todman, 1995). The improvement of students' conceptual understanding was gathered by giving all of student from both of class an objective test before and after the implementation of the textbook based on STEM with Quranic integration (Komarudin et al, 2017). The pretest and posttest were given to students in the form of 8 test questions, each question score 1 point, so the highest pure result is 8. The scores shown in the Table 3 are the pure test results before being converted into final scores.

Table 3. Pretest-posttest Result

	Class of experiment	**Class of control**
Average of pretest score	2.97	3.25
Average of posttest score	5.43	5.16
N gain	0.35	0.28

Students' conceptual understanding for both classes has increased, but it has differences. The increase in class of experiment is higher than the class of control. The $N\ gain$ The value is processed through the data of pretest and post-test scores, which have been collected by all participants. From the results, it is known that the average pretest score for the experimental class is 2.97 and the average pretest score for the control class is 3.25. The posttest score of the experimental class was 5.42 and the control class was 5.16. In this way, the $N\ gain$ value for each class can be calculated, namely 0.35 for the experimental class and 0.28 for the control class.

Based on the effectiveness analysis equation, by comparing the $n\ gain$ of the experimental class to the $N\ gain$ In the control class, the effectiveness value is obtained with a score of more than 1. Differences in students' conceptual understanding can be caused by the material presented in the STEM-based textbook integrated into the Quran (Komarudin *et al.*, 2017). The textbook material has been integrated with the science content of traveling and standing waves, with examples from real life, which helps students to understand easily. This improvement is also probably caused by STEM activities that are contained in the STEM-based textbook integrated with the Quran. It was mentioned that STEM activities improve conceptual understanding in many studies (Bakirci, 2022). In addition, activities such as creating a simple seismograph that is presented in the STEM-based textbook could help students to combine the science concept and their creativity and gain some experience with learning by doing. Therefore, it has been determined that studies in STEM approaches help students think quickly and produce solutions (Tiryaki & Adiguzel, 2021).

Conclusion

Based on research results and discussion, it can be concluded that A product has been developed in the form of a STEM-based textbook integrated with the Quran in wave material for SMA/MA students. The STEM-based textbook integrated with the Quran on wave material developed is valid with a score percentage of 77.3% in the category of suitable for use. STEM-based textbooks integrated with the Quran in wave material have proven to be effective in increasing students' conceptual understanding.
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