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DEVELOPMENT OF A DIGITAL PHYSICS TEXTBOOK BASED ON MULTIREPRESENTATION TO HELP STUDENTS APPLY THE CONCEPTS OF SOUND AND LIGHT WAVES

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ABSTRACT

The aim of this study is to develop a digital physics textbook based on multirepresentation to assist grade 11 students in applying the concepts of sound and light waves in high school/islamic senior high school (SMA/MA) and to determine the feasibility and response of the students to the developed textbook. The research method used in this study is Research and Development and refers to the Borg and Gall development model. The digital textbook was validated by expert validators and two high school physics teachers. The digital textbook was tested on a limited basis with 26 students. The validation results of the digital textbook by expert validators and two high school physics teachers obtained an overall average score of 3.72 out of a scale of 4.00, which means that the digital textbook meets the valid criteria. The limited test results on 26 students showed that the percentage of the digital book trial results reached 92.66%, which means that the digital textbook met the practical criteria. These results indicate that the developed digital textbook is feasible for wider trials as it meets both valid and practical criteria.

Reseach Paper

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Keywords: Digital Textbook, Multirepresentation, Concept Application.

INTRODUCTION

The 21st century has brought significant changes in rapid technological advancements in all sectors, from the economy, transportation, information, and education (Redhana, 2019). In the education sector, the rapid development of science and technology demands students to have several 21st-century life skills known as the 4Cs, namely Critical Thinking, Communication, Collaboration, Creativity.

The fast-paced technological progress requires every individual to move faster to keep up with it, including self-development (Jayadi, et al., 2020). Technological progress has made schools ready to face all the changes that occur, including the learning patterns that schools conduct for their students (Somantri et al., 2019). This must be supported by the teacher's ability to utilize technology, including Interactive Multimedia (Sari et al., 2020). The existence of interactive learning media can reduce student boredom during lectures (Amalia, 2019). On the other hand, physics is still considered a challenging natural science discipline by students.

The formation of such perceptions indirectly affects students' thinking, making them feel inadequate before learning and causing them to memorize formulas instead of understanding them. Physics is one of the subjects in high school that serves as a means to help students solve problems in daily life. Several studies have shown the importance of understanding concepts in-depth so that they can be applied to problem-solving (Sutopo, 2016; Toh & Tsoi, 2008; Arends, 2008). Therefore, students are expected to have a good understanding so that they can apply concepts to problem-solving.

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One way to improve students' understanding is by providing learning experiences that interpret information in various representation forms (Purwaningsih, 2012; Doyan et al., 2018). Representation can be in the form of mathematical, graphical, verbal, or visual representations (Doyan et al., 2018). Mathematical representation is a form of representation related to symbol presentation, equations, formulas, and data processing (Setyawati et al., 2020). Visual representation is a form of representation in a sketch or picture based on a description that has been elaborated. Verbal representation is a representation in the form of an explanation in words or sentences (Murtianto et al., 2019).

Graphical representation is a form of representation of the relationship between one variable with another variable based on both verbal and mathematical explanations given (Arifah et al., 2020). Multirepresentation has three main functions, namely complementary, interpretive boundaries, and helping to deepen understanding (Doyan et al., 2018). Safitri et al. (2020) stated that multirepresentation-based learning can improve students' understanding. This means that involving various forms of representation in learning can impact students' learning outcomes. The use of various representations in learning/material will make learning more meaningful (Susilaningsih et al., 2019).

Considering the current learning conditions, it is necessary to develop digital textbooks that can guide students in understanding the concepts of physics. Textbooks are a set of materials compiled by considering students' characteristics and needs so that learning goals can be achieved. Textbooks should be developed by adjusting to students' needs and characteristics and contain 21st-century skills (Lovisia & Arini, 2019), namely critical thinking, creativity, collaboration, and communication skills (Oktavia, 2019), which will help students learn abstract concepts, especially in physics, more concretely (Sundaygaram, et al., 2018).

The presence of digital textbooks is expected to create an engaging and conducive learning atmosphere that students can use independently by utilizing flipbook maker applications (Sugianto et al., 2013). Flipbook maker is an application used for creating e-books, e-modules, e-papers, and e-magazines. By using this application, textbooks are not limited to texts and images, as it can also include graphics, sounds, links, and videos. When reading, it feels like opening a physical book due to the animation effect when flipping pages (Hidayatullah, 2016).

Based on the explanation above, it is deemed necessary to develop a multi-representation-based digital physics textbook to assist students in applying the concepts of sound and light waves for grade 11 high school. The development of this digital textbook is expected to aid students in learning the concepts of sound and light waves in a clear and easily understandable manner.

LITERATURE REVIEW

Textbooks are one of the main sources for students to learn (Nieminen et al., 2012). According to the National Center for Vocational Education Research Ltd/National Center for Competency Based Training, a textbook is any form of material used to assist teachers/instructors in conducting teaching and learning activities in the classroom (Nugraha, et al., 2013). Meanwhile, according to Akbar (2013), a textbook is a standard reference book for a specific subject. The functions of a textbook include: (a) providing guidance for teachers to direct students' activities in the learning process, as well as the competencies that should be taught to students, (b) serving as a guide for teachers and students to direct all their activities in the learning process, as well as the competencies that should be learned/mastered, and (c) serving as an evaluation tool for learning achievement/mastery (Ministerial Regulation No. 22 Year 2006).

Developing textbooks is very important for teachers to make learning more effective, efficient, and in accordance with the competencies to be achieved. Through a good textbook, students can master competencies at their own learning pace (Munawwarah, et al., 2017). Therefore, textbooks developed by teachers are expected to make students more active in learning activities to achieve competencies. Currently, textbooks are not

only packaged in print form but can also be packaged in digital or electronic form known as e-books. According to Gardiner (in Prasetya, 2015), e-books are defined as book publications in digital form, consisting of text, images, or both, and are easy to read on computers or other electronic devices.

Representation is a configuration (form or arrangement) that can depict, represent, or symbolize a way. Representation is also something that depicts, represents, or symbolizes an object or process (Rosengrant, et al., 2007). According to Ainsworth (1999), the use of multi-representation learning plays an important role in creating effective learning and can increase students' interest in learning. Based on research results on the use of multi-representation in learning, all of them show positive results, namely that the use of multi-representation is indeed important in the success of solving problems in physics (Kohl et al., 2007).

METHODS

This research and development method was conducted based on the research and development steps according to Borg & Gall model (Sukmadinata, 2016). However, in this study, only five out of the ten stages developed by Borg & Gall were carried out due to time and cost constraints. These five stages are: (1) Research and information gathering, (2) Planning, (3) Draft product development, (4) Initial field testing, and (5) Revision of test results. The development design can be seen in the following **Figure 1**.

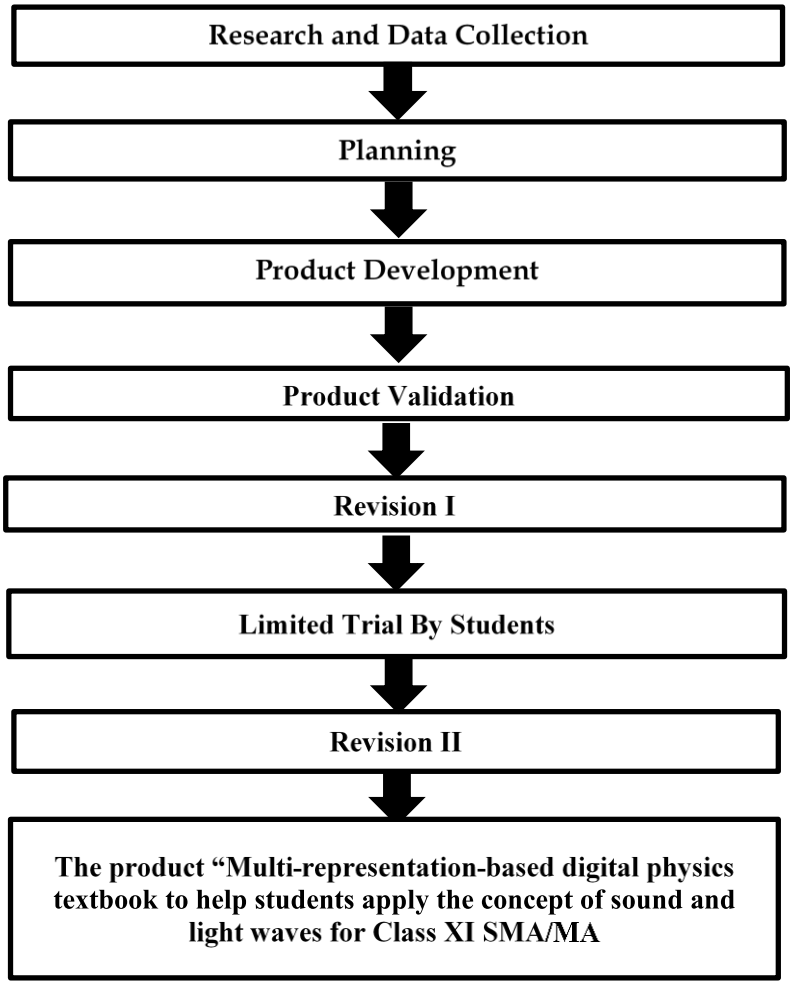

Figure 1 Design of Multi-Representation-Based Digital Textbook Development (adapted from the Borg and Gall model)

The analysis technique used to analyze the validation data is the calculation of the average score. Technical analysis validation in this development, the assessment criteria use a score of 1 to 4, score 1 indicates the lowest score and score 4 indicates the highest score.

$$\bar{X} = \frac{\sum \bar{x}}{n} \quad (1)$$

The average analysis criteria used can be seen in Table 1.

Table 1 Criteria for Expert and Teacher Validation Data Analysis Results (adapted from Arikunto, 2013)

Score achievement	Category
3,26 – 4,00	Valid
2,51 – 3,25	Pretty valid
1,76 – 2,50	Less valid
1,00 – 1,75	Invalid

While the analysis in the trial was limited to using percentages. Data were obtained from questionnaire answers in limited trials by students.

$$P = \frac{\sum P}{n} \, x \, 100\% \quad (2)$$

The criteria for evaluating limited trials by students are in Table 2.

Table 2 Criteria for the Results of Limited Trial Data Analysis by Students (adapted from Arikunto, 2013)

Score achievement	Category
76% – 100%	Practical
51% – 75%	Practical enough
26% – 50%	Less practical
0 – 25%	Not practical

The research is considered successful if from processing validation questionnaire data and limited trials by students, scores of 2.51 - 4.00 and 51% - 100% respectively are obtained.

RESULTS AND DISCUSSION

This development research produced a product in the form of a multi-representation-based digital physics textbook to help students apply the concept of sound and light waves in class XI SMA/MA. Product development is made through several predetermined stages, namely research and data collection, planning, product draft development, product validation, and limited trials.

Results of Digital Textbook Development

This digital textbook has advantages including, (a) the textbook is equipped with understanding of concepts through multi-representation, (b) the textbook is always preceded by an interesting phenomenon and a demonstration so as to make students more interested and active, (c) This textbook is in the form of a textbook. digital teaching so that it makes students more happy to learn independently, (d) textbooks are equipped with simulations (PhET), videos, animations and are accompanied by Learning Cycle learning steps (5 M). The following shows a digital textbook that is operated in .swf format.

Due Diligence Result Data

The results of the feasibility test of textbooks developed based on the assessment of media and material expert lecturers can be seen in the following table:

Table 3 Data from Textbook Content Assessment Results

Rated aspect	Evaluation			
	V1	V2	V3	Overall average
Material	3,71	4,00	4,00	3,90
Evaluation questions	4,00	3,67	3,67	3,77
Average	**3,86**	**3,83**	**3,83**	**3,84**

Table 4 Data on the results of the textbook presentation assessment

Rated aspect	Evaluation			
	V1	V2	V1	Overall average
Serving Technique	3,43	3,86	3,71	3,67
Presentation Completeness	3,40	4,00	4,00	3,8
Average	**3,41**	**3,92**	**3,85**	**3,73**

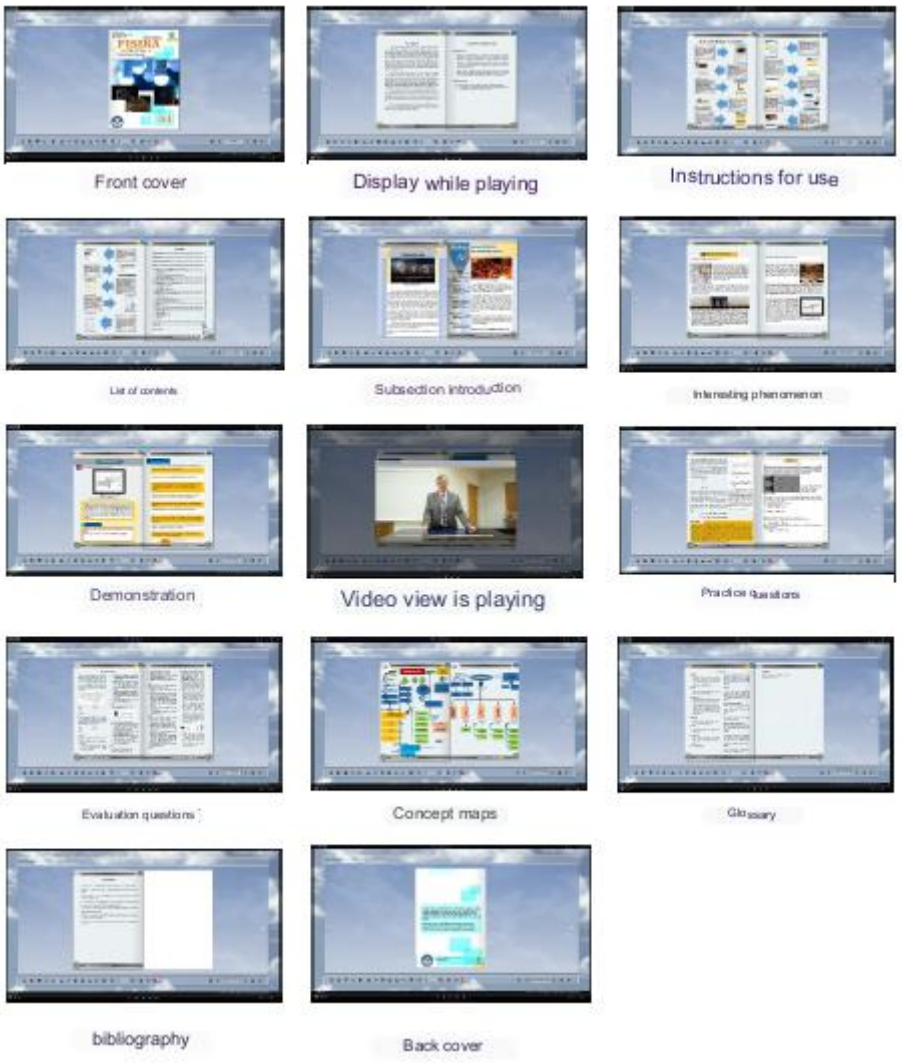

Figure 2 Display of internal textbooks operated in .swf format

Table 5 Data on the results of the language assessment used in textbooks

Rated aspect	Evaluation			
	V1	V2	V1	Overall average
language used	3,00	3,50	3,50	3,33
Use of terms, symbols, symbols	4,00	4,00	4,00	4,00
Conformity with Indonesian Language Rules	3,00	4,00	4,00	3,67
Average	**3,33**	**3,83**	**3,83**	**3,67**

Table 6 Flipbook Media Result Data

Rated aspect	Evaluation			
	V1	V2	V1	Overall average
Instructional quality	3,75	4,00	3,75	3,83
Technical quality	3,80	3,40	3,20	3,46
Average	**3,86**	**3,70**	**3,48**	**3,65**

Table 8. Recapitulation of Textbook Validation Results by the Validator

Aspect	Score	Criteria	Information
Presentation	3,84	Valid	May be used without revisions or very minor revisions
Serving Technique	3,73	Valid	May be used without revisions or very minor revisions
language used	3,67	Valid	May be used without revisions or very minor revisions
Media Flipbook	3,65	Valid	May be used without revisions or very minor revisions
Overall average	**3,72**	**Valid**	May be used without revisions or very minor revisions

The content presentation aspect of the textbook achieved a score of 3.84 with a valid criteria and can be used without or with very minimal revisions. The technical aspect of the textbook presentation obtained a score of 3.73 with a valid criteria and can be used without or with very minimal revisions. The language aspect used in the textbook achieved a score of 3.67 with a valid criteria and can be used without or with very minimal revisions. The flipbook media aspect used obtained a score of 3.65 with a valid criteria and can be used without or with very minimal revisions.

Based on Table 7, it can be seen that the overall average score achievement for the four evaluated aspects is 3.72, which meets the valid criteria without or with very minimal revisions based on quantitative statistical analysis adapted from (Arikunto, 2013). However, the textbook still needs improvement. Based on the comments and suggestions from validators on the textbook, among others, the concept map should not be placed at the front as it makes students perceive learning as easy and less profound. Then, in the book section (beginning of the subchapter), it should be started with interesting phenomena and accompanied by questions that make students more interested in reading it. In the teacher's book, a syllabus and lesson plan should be provided to make the teacher better understand the purpose and learning of the textbook that has been created. In the textbook cover, the curriculum should be included so that the curriculum used in the textbook is known. Furthermore, sample questions and exercises need to be added to the textbook.

Limited Trial

Based on Table 8, the percentage of limited trial results of the textbook according to students as potential users is 92.66%, indicating that the textbook meets practical criteria based on quantitative statistical analysis adapted from (Arikunto, 2013). Therefore, based on the data analysis obtained, the developed textbook is considered practical, although there are some things that need to be improved.

Based on comments and suggestions from students as potential users of the textbook, they include language, material, images, cover, and presentation. Students revealed that the language used in the textbook is easy to understand. In terms of material, they mentioned that the material per page is too dense, but in terms of content, it is easy to understand. Furthermore, students' feedback on the presented images explains that they understand the concept better through the images.

Table 7 Data on Limited Test Assessment Results by Students

Criteria	Answer	
	Yes	No
The appearance (color, design) of the textbook is attractive	24	2
The language used in textbooks is easy to understand	25	1
The size of the letters and characters in the textbook are appropriate	22	4
The symbols or symbols used are consistent	26	0
The pictures in the textbook are clear so they can help understand the material	25	1
Demonstration activities in the book are easy to understand and do so that they can help understand the concept	23	3

The experimental activities in the book are easy to do so they can help understand the concept	24	2
The activity steps in the textbook help understand the concept	23	3
The description of the material is quite clear	23	3
Evaluation questions are easy to understand	24	2
The book that was developed made it easy for me to understand the material of sound and light waves	26	0

Table 8 Data Summary of Limited Trial Results by Students

Criteria	Average results (%)	Note
The appearance (color, design) of the textbook is attractive	92,30	Practical
The language used in textbooks is easy to understand	96,15	Practical
The size of the letters and characters in the textbook are appropriate	84,61	Practical
The symbols or symbols used are consistent	100	Practical
The pictures in the textbook are clear so they can help understand the material	96,15	Practical
Demonstration activities in the book are easy to understand and do so that they can help understand the concept	88,46	Practical
The experimental activities in the book are easy to do so they can help understand the concept	92,30	Practical
The activity steps in the textbook help understand the concept	88,46	Practical
The description of the material is quite clear	88,46	Practical
Evaluation questions are easy to understand	92,30	Practical
The book that was developed made it easy for me to understand the material of sound and light waves	100	Practical
Overall percentage yield	**92,66**	**Practical**

CONCLUSION

Based on the research and data analysis, the digital textbook based on multirepresentation for helping students to apply the concepts of sound and light waves in grade XI of high school has been declared valid for use as a learning material. The average validation score from experts was 3.72 out of 4, which met the validity criteria without requiring any or only minor revisions. The limited test results with 26 students showed an average percentage of 92.66%, which indicated that the textbook met the practical criteria. Therefore, for further research, it is worth testing the textbook on a larger scale to evaluate its effectiveness in helping students apply the concepts of sound and light waves.

Author's declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

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Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interest.

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