Received : 19 September 2019
Revised : 17 October 2019
Accepted : 19 October 2019
Online : 22 October 2019
Published: 30 December 2019

DOI: doi.org/10.21009/1.05206

Textbooks Equipped with Augmented Reality Technology for Physics Topic in High-School

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Abstract

This article aims to publish research results on the development of physics textbooks equipped with 3D media based on Augmented Reality technology. AR Technology can provide solutions when students face difficulties illustrating physics material in physics learning textbooks. This research uses the research & development method of the Dick & Carey model. The resulting book displays physics material in multi representations with verbal forms, pictures, tables, graphs, mathematical equations, and 3D media. Augmented Reality technology-based multi representation is displayed with a marker that is scanned through a smartphone application with an Android system. The scanning process requires an average of two seconds from each marker. The time of this scan shows that the media produced is more effective and efficient when compared with the activities of searching and downloading animations or videos by students. The feasibility of the book was tested with a Likert scale questionnaire instrument. For material, the worthiness was 71.45% while 93.3% for the media. The trial results are limited to five materials giving N-Gain values ranging from 0.3 to 0.47. Based on these results it can be concluded that the book model enriched with 3D media with AR technology is already feasible as a textbook in learning physics.

Keywords: augmented reality, textbooks development, physics, high-school

INTRODUCTION

The internet is a collection of computer networks so users can share information with more comprehensive sources. The internet is one type of Information and Communication Technology (ICT) media (Darimi 2017). ICT is increasingly developing so that it affects human life in various aspects (Restiyani 2014). It is based on the results of a 2016 Indonesian Internet Service Providers Association (APJII) survey of internet users in Indonesia around 132.7 million people consisting of ages of 10-55 years and over. Internet use is most often used by students and students (APJII 2016).

The utilization of ICT in learning has progressed. More advanced technology is needed to produce an interactive learning process. One of the technologies currently being developed to support learning is Augmented Reality (AR) technology. AR technology can combine a 3D object into the real world (real world) through a computerized process so that it looks real to the user (Kamelia 2015).

A prevalent phenomenon from the existence of AR technology is the Pokemon Go game. The use of AR technology can make Pokemon Go game players as if they were meeting, capturing, and fighting the Pokemon monster characters in the Pokemon Go game. The Pokemon monster character in the game is a visual object produced by AR technology and displayed in the real world through an Android-

based smartphone device (Tuela 2017). Monster characters will appear if there are markers recognized by the device's camera to activate AR content (Wicks 2017).

Use must have an AR application on mobile phones with the Android operating system so that the mobile camera can translate markers into virtual information (Ambarwulan 2016). Another advantage of AR technology is that it allows digital content (audio, video, 2D and 3D objects) to be seen integrated into the real world through a device. AR makes content in the form of three dimensions (3D) so that it can visualize things that are hard to see. AR can also bring virtual objects to the real world in realtime. AR technology has been developed on smartphone devices that have navigation features supporting AR so that it can be implemented on popular devices such as Android so that it is easily accessed by the public (Qumillaila 2017).

Rapidly advancing technological advancements encourage educators to continue to innovate and make efforts to utilize the results of AR technology into the learning process. The development of AR-based learning media makes students not fixated on conventional media. The media is one of the important factors in the successful transformation of the material presented (Mustaqim 2017).

AR media in learning can display 3D forms in full and tangible to clarify the material in teaching materials (Wulansari 2013). The submission of material with the addition of AR will make students more comfortable to understand the concept of the material. Students can learn concepts quickly, effectively, and interactively. AR can also train students' creativity in learning activities that are not boring (Mantasia 2013).

AR learning media are made with Markerlessbased Technique so that the interface display becomes attractive. The Augmented Reality application can be used on smartphones with the Android Operating System (Ambarwulan 2016). AR media can be as support in learning activities in the classroom and is useful for enriching information when used outside the classroom (Putri 2016). So that AR media enables learner-centered learning and creates opportunities for collaboration that foster a more in-depth understanding of content.

The use of AR media in learning can be integrated into books as a media capable of displaying 3D objects virtually on mobile phone devices so that learning becomes more effective and efficient (Ahmadi 2017). By integrating AR into books, students can observe many objects and phenomena displayed in 3D (Eyendy 2012). AR can arouse students' interest in understanding the material delivered with three-dimensional visual representation (Prasetyo 2014). Previous research stated that the developed AR book is eligible and suitable for use in Physics learning (Permana et al. 2018; Bakri et al. 2018). Based on these studies, that AR can be applied to textbooks to minimize misconceptions.

Misconceptions can occur in various textbooks. Textbooks can be effectively used if they are integrated with specific models or strategies (Saputri, Fadilah, Wahyudi 2016). Many physics textbooks contain concepts of understanding (text), mathematical equations, writing symbols, graphic images, and diagrams (Nurhayati 2015). It allows misconceptions and errors (Respatiningrum 2015). One way to minimize misconceptions is by applying multi-representations to the textbooks that will be used.

Textbooks supported by multi-representations can help students in understanding the concepts being learned. Multi-representation has high effectiveness in instilling the concepts of learning materials so that multi-representation can minimize misconceptions contained in textbooks (Suhandi 2012). Multirepresentation is a form of arrangement of material concepts through various forms, such as verbal descriptions, mathematical symbols, images, and graphics to facilitate the process of delivering information to students (Widianingtiyas 2015). By using multi representations, the learning process can make students able to gather information, seek explanations, and solutions to build understanding of concepts. Students are also able to change the form of problems from graphics into other forms such as verbal, drawing, and using mathematical equations (Hasbullah 2017). Multi-representation can also be applied to textbooks. Textbooks supported by multi-representations are said to be appropriate as complimentary books for learning physics (Silaban 2016; Nurhayati 2016, Piranti 2016).

The 3D media with AR technology integrated into books will enrich multi-representation so that students can visualize objects and phenomena in learning physics. It can increase learning motivation, and the learning process becomes more interesting and effective (Septianita 2014). AR can also make it easier for students to understand the material delivered with a three-dimensional visual representation

(Eyendy 2012). Physics textbooks need to be developed with additional representation through AR technology. Its study aims to produce physics textbook models that are equipped with augmented reality technology.

METHODS

To produce books that are equipped with augmented reality technology, research, and development method is conducted. This study uses the Dick & Carey model, the first step to the ninth step (Walter Dick 2001). The research instrument consisted of a book eligibility instrument and students' N-Gain measurement instruments. The feasibility instrument was made in the form of a Likert scale questionnaire. The n-gain measurement instrument is made in the form of multiple-choice questions.

RESULTS AND DISCUSSIONS

The augmented reality physics book discusses material for Class X Even Semesters. This book contains instructions for using the book, concept maps, learning objectives, preliminary tests, introduction, description of the material, conclusions, summaries, practice questions, formative tests, glossaries, and bibliography. Description of the material is enriched in multi representations in the form of images, videos, or 3D animations based on AR, data, graphics, and mathematical equations, and physics concept texts. 3D video or animation is displayed from the image markers in the book by scanning the image with an android smartphone. 3D animation is created using a blender application, which is continued to make an augmented reality-based application using the Unity 3D software.

Physics Book Description

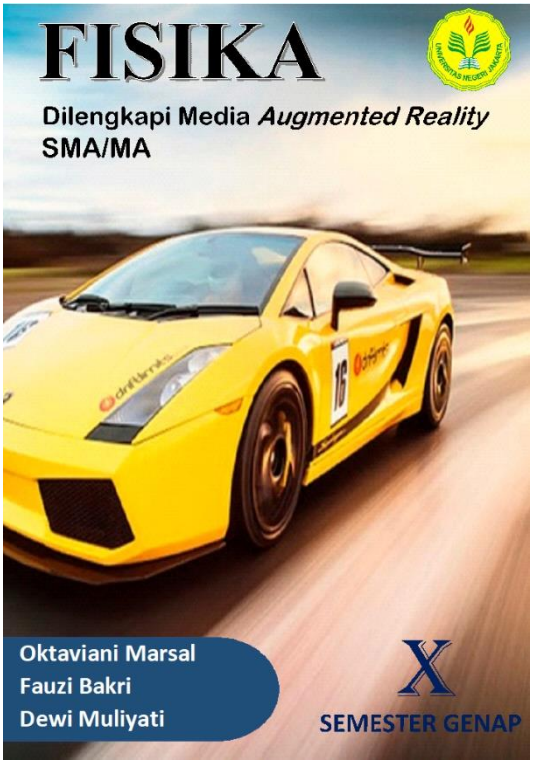


FIGURE 1. Front cover

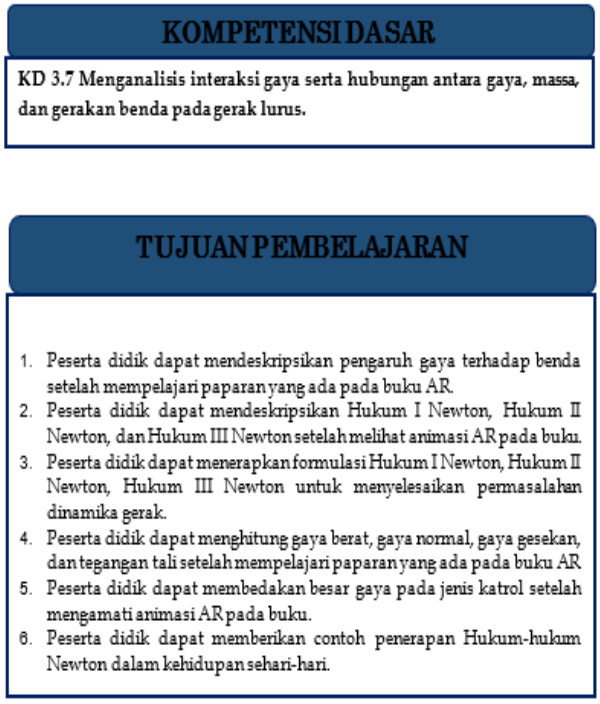
BAB 1 HUKUM-HUKUM NEWTON

Gambar 1.1 mendorong mobil
Sumber: basyirnadzir.blogspot.co.id

Pada materi kelas X Semester Ganjil sudah membahas tentang kinematika gerak lurus, gerak parabola, dan gerak melingkar. Dalam kajian kinematika, benda seperti benda titik yang tidak memperhitungkan massa benda. Sehingga benda bergerak dengan besaran-besaran gerak yang mempengaruhi. Dalam kenyataannya, gerak benda di pengaruhi oleh massanya. Gaya diberikan dengan massa yang berbeda maka dengan semakin besar massa semakin besar gayanya.

Bab ini akan mempelajari salah satu cabang ilmu fisika, yaitu dinamika. Dinamika adalah ilmu tentang gerak suatu benda yang bermassa akibat adanya pengaruh gaya. Dinamika dapat digambarkan dengan Hukum-Hukum Newton.

FIGURE 2. Introduction in the textbook



KOMPETENSI DASAR

KD 3.7 Menganalisis interaksi gaya serta hubungan antara gaya, massa, dan gerakan benda pada gerak lurus.

TUJUAN PEMBELAJARAN

1. Peserta didik dapat mendeskripsikan pengaruh gaya terhadap benda setelah mempelajari paparan yang ada pada buku AR.
2. Peserta didik dapat mendeskripsikan Hukum I Newton, Hukum II Newton, dan Hukum III Newton setelah melihat animasi AR pada buku.
3. Peserta didik dapat menerapkan formulasi Hukum I Newton, Hukum II Newton, Hukum III Newton untuk menyelesaikan permasalahan dinamika gerak.
4. Peserta didik dapat menghitung gaya berat, gaya normal, gaya gesekan, dan tegangan tali setelah mempelajari paparan yang ada pada buku AR
5. Peserta didik dapat membedakan besar gaya pada jenis katrol setelah mengamati animasi AR pada buku.
6. Peserta didik dapat memberikan contoh penerapan Hukum-hukum Newton dalam kehidupan sehari-hari.

FIGURE 3. Learning objectives

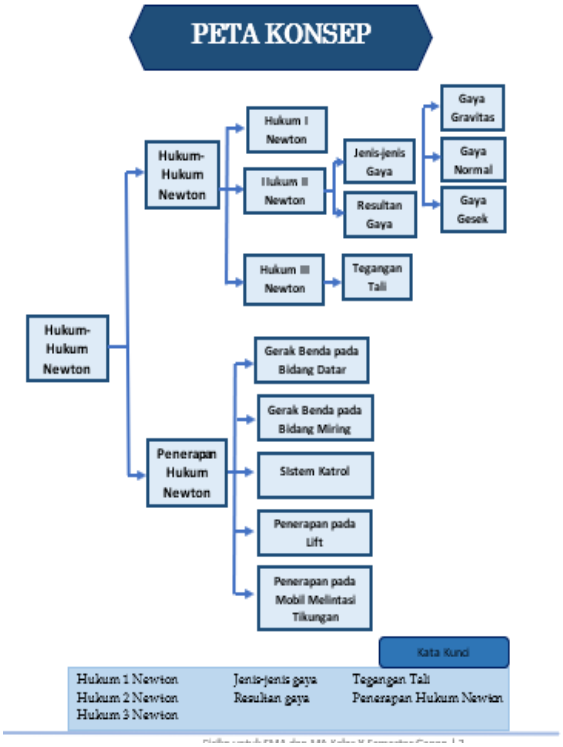


FIGURE 4. Concept Mapping

A. Hukum-Hukum Newton Tentang Gerak

Gaya merupakan fenomena yang sering terjadi dalam kehidupan sehari-hari. Misalnya jika ada sebuah mobil dan sebuah motor yang mogok, maka diperlukan suatu gaya untuk menjalankannya. Gaya yang diberikan pada mobil akan lebih besar dibandingkan dengan motor karena semakin besar massa benda akan semakin besar pula gayanya. Pada kasus ini, mobil memiliki massa yang lebih besar dibandingkan dengan massa motor, sehingga gaya yang diberikan lebih besar pada mobil daripada motor. Gaya disimbolkan dengan F yang berasal dari kata *"force"*.

Pada abad ke-17 Sir Isaac Newton mengembangkan penelitian dari seorang fisikawan asal Italia yaitu Galileo Galilei, sehingga dapat merumuskan tiga hukum penting yang berhubungan dengan gaya dan massa, yaitu Hukum I Newton tentang kelembaman, Hukum II Newton tentang gerak, dan Hukum III Newton tentang keseimbangan statis. Ketiga hukum ini disebut Hukum-Hukum Newton tentang Gerak.

1. Hukum I Newton

Gambar 1.3 Mobil tabrakan

Sir Isaac Newton

10 fakta unik tentang Sir Isaac Newton (1643-1727)

1. Newton terlahir premature.
2. Newton terlahir dari keluarga petani dan hampir menjadi petani.
3. Newton tidak langsung mempublikasikan penemuannya.
4. Newton mendapatkan inspirasi dengan melihat jatuhnya sebuah apel dari jendela rumahnya.
5. Newton merupakan seorang alkemis yang mempelajari cara mengubah logam dasar menjadi emas dan perak.
6. Newton seorang yang religious.
7. Newton lebih banyak menulis tentang agama daripada matematika dan sains.
8. Newton pernah menjadi politisi (anggota parlemen) selama satu tahun.
9. Newton memiliki nafsu makan yang tinggi.
10. Newton seorang yang gemar bertinju.

FIGURE 5. Content

Tabel 1.1 Hubungan antara gaya dan percepatan

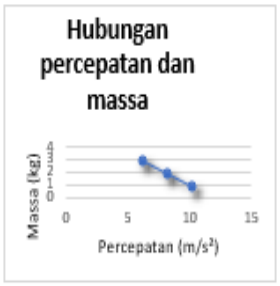
Percobaan ke-	Massa (kg)	Gaya (N)	Kecepatan (m/s)	Waktu (s)
1	1	10		
2	1	20	30	1,5
3	1	40	40	1

Chart Area

Tabel 1.2 Hubungan antara percepatan dan massa

Percobaan ke-	Percepatan (m/s^2)	Massa (kg)	Gaya (N)
1	10	1	10
2	8	2	16
3	6	3	18

Gambar 1.5 Grafik hubungan gaya dan percepatan



Gambar 1.6 Grafik hubungan percepatan dan massa

FIGURE 6. Table and Graphics on textbooks

a)

b)

ARa

c)

FIGURE 7. a) Images bearing the ARA logo; b) 3D animation; and c) ARA logo

FIGURE 7a) can display 3D animation by scanning images through the AR Motion Dynamics application on a smartphone. 3D animation will only appear when scanning images correctly. The 3D animations for images of people pushing cars can help students to describe Newton's third law.

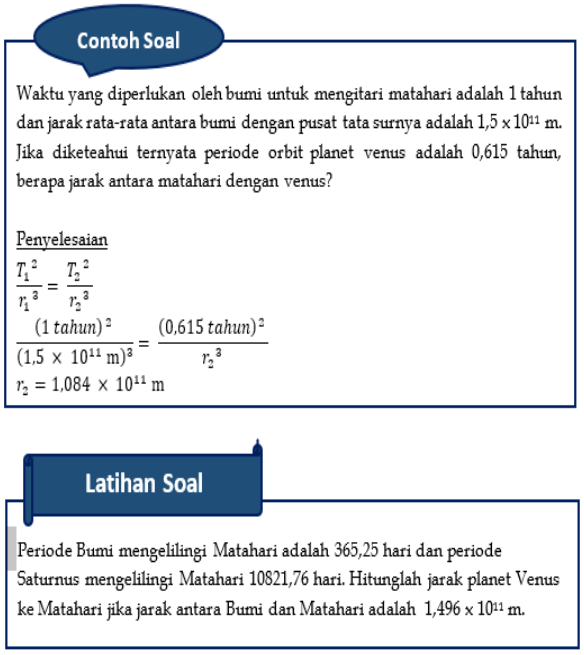


FIGURE 8. Examples and practice questions

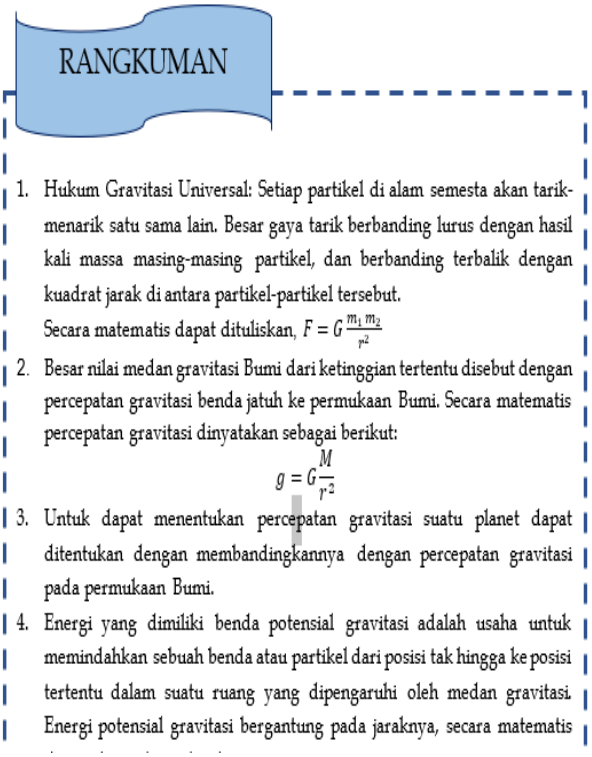


FIGURE 9. Content Summary

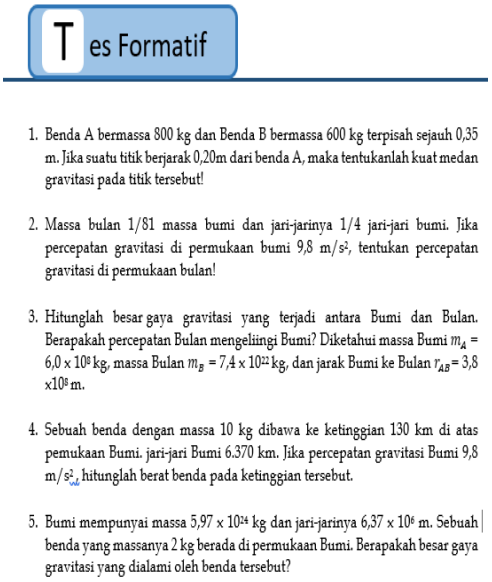


FIGURE 10. Formative Test

Formative Evaluation of Book Products

The formative evaluation of the book model equipped with AR technology was carried out for the development of the book model so that it was suitable for use in learning physics. In the formative evaluation stage, a validation test is conducted by material experts and media experts using a Likert scale questionnaire instrument. This validation stage aims to determine the feasibility of a book that is equipped with augmented reality technology.

Based on the Likert scale interpretation, obtained the feasibility interpretation of the material by 71.33%. The resulting book product is judged to be materially feasible. The results of the validation and suggestions from the validator are more emphasized in writing EYD on the book.

TABLE 1. Feasibility test results by the Material Expert

Aspect	Percentage	Interpretation
Presentation of material in textbooks	77.6%	Good
Material suitability	70.4%	Good
Language of writing material	66%	Good
Average	71.33%	Good

The Likert scale on the aspect of the media gives the interpretation of 87.6% feasibility. These results indicate that the developed book product is considered very feasible as a learning medium.

TABLE 2. Feasibility test results by the Media Expert

Aspect	Percentage	Interpretation
The textbook component	85.5%	Very Good
The size of the textbook	100%	Very Good
Book cover page design	80%	Very Good
The layout of the contents of the book	100%	Very Good
The typography of book content	90%	Very Good
Illustration of book content	82.9%	Very Good
Augmented reality media	74.5%	Very Good
Average	87.6%	Very Good

The product contains five physics chapters that were tested on students to get the results of the N-Gain value. In TABLE 3, the results of the N-Gain value from each chapter are presented.

TABLE 3. N-Gain Value

Aspect	N-Gain
Newton's Law	0,30
Newton's Law of Gravity	0,36
Work and Energy	0,40
Momentum and Impuls	0,35
Simple harmonic motion	0,47

Based on TABLE 3, N-Gain can be obtained in the medium category in each material discussion. The N-Gain results on the topic of Newton's Law are 0.30; on the topic of Newton's Law of Gravity are 0.36; on the topic of Work and Energy are 0.40; on the topic of Momentum and Impuls are 0.35, and on the topic of Simple harmonic motion are 0.47. It can be concluded that the Book with AR technology can be said to be feasible as a multi-representation based learning media.

CONCLUSIONS

Based on the results of the formative evaluation of media, material and learning feasibility, it can be concluded that textbooks equipped with Augmented Reality technology are considered appropriate as physics textbooks. Based on the results of formative evaluation of media, material and learning feasibility, it can be concluded that textbooks equipped with Augmented Reality technology are considered feasible as physics textbook.

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