

Development of An Android-Based Physics *E-Book* with A Scientific Approach to Improve The Learning Outcomes of Class X High School Students on Impulse and Momentum Materials

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Abstract

The use of technology during a pandemic can be in the form of using e-books in learning activities. This research is Research and Development (R&D) which produces a product in the form of an Android-based physics e-book with a scientific approach. The aim of this study is to develop and determine the feasibility and effectiveness of e-books in improving learning outcomes on impulse and momentum materials. The development of this physics e-book uses a 4D model according to Thiagarajan, namely define, design, develop, and deploy. Results based on 4D model steps are (1) Define to produce an analysis of the needs of students during online learning, (2) Design to produce a product, namely a physics e-book, and (3) Develop to produce validation and the final product, and (4) Deploy of products is distributed in a limited way to physics teachers in Jatinom Senior High School. Based on expert consideration, the average product feasibility on aspects of material/content, language and images, e-book content design, and language included in the very high category. The physics e-book applied to students class X Mathematics and Natural Sciences in Jatinom Senior High School. Student learning outcomes increased in the moderate category after carrying out physics learning with e-books. Thus, an Android-based physics e-book with a scientific approach is feasible and efficient to be applied in physics learning on impulse and momentum material to improve student learning outcomes.

Keywords: E-books, Android, Scientific Approach, Learning Outcomes

INTRODUCTION

The concepts of impulse and momentum are closely related to everyday life. Many natural phenomena are related to the concepts of impulse and momentum. However, 90.91% of students still experience problems in understanding physics material, especially momentum and impulse material (Anggraeni & Suliyanah, 2017; Savira, Budi, & Supriyati, 2019). This happens because of students' ability to understand different concepts (Rosa, Cari, Aminah, & Handhika, 2018).

Many students still memorize formulas compared to understanding the concepts of impulse and momentum (Anggraini, 2018). Students also have difficulty in applying the concepts of impulse and momentum in problem

solving (Bryce & MacMillan, 2009; Pride, Vokos, & McDermott, 1998). In addition, the misunderstanding of students on impulse and momentum material that often occurs is that students think that impulse is the same as momentum (Putranta & Supahar, 2019). Thus, the material about impulse and momentum are included in abstract physics concepts (Ekercioğlu & Kocakulah, 2008).

Abstract impulse and momentum material causes students to have difficulty in understanding the concept. Students are able to understand abstract physics concepts that can be visualized into interactive teaching materials. Interactive teaching materials can support students to understand the concept of impulse and momentum.

The reality that occurs in the impulse and momentum learning process is still not as expected. Teachers still apply power point media that displays images and text only in momentum and impulse learning (Kaniawati, 2017). This is in accordance with the results of observations on physics learning at X MIPA 4 (Science major) class in SMA N 1 Jatinom (Senior High School), teacher only using power point media . The power point media used by the teacher displays text, images and videos related to the material described. Students still rely on the explanations given by the teacher so that learning activities are still teacher centered. Traditional teaching methods by teachers make the concepts of impulse and momentum a complex topic (Şekercioğlu & Kocakulah, 2008).

Current technological developments can be used to develop interactive teaching materials. One of them is printed textbooks that can be developed into digital textbooks or commonly known as electronic books. *E-book* is a type of electronic book in softcopy and consists of images, text, animations that can be read on electronic devices such as laptops or smartphones (Gaol, Serevina, & Supriyati , 2019; Utomo, Yelianti, Muswita, & Wicaksana ,2018). Learners can access *e-books* anytime and anywhere (Hidayat, Suyatna, & Suana, 2017).

There have been many variations of physics e-books, one of them is an android-based e-book. Android-based e-books have an attractive and flexible appearance so that many students interested. (Taqwa, Utami, & Rivaldo , 2019). The use of Android-based e-books equipped with videos and pictures attracts the attention of students and supports students in getting different experiences in the learning process (Hasbiyati, Sudiarti, & Hikamah, 2019). E-books trigger students' curiosity about physics which is very closely related to daily life (Sari, Rahim, Sundari, & Aulia, 2022). Thus, students can use smartphones positively and apply technology in education.

E-books can be developed with a learning approach that supports learning to be more focused and structured. A learning approach that can be used as an alternative for teachers to use

is a scientific approach. The application of a scientific approach with 5M stages (Observing, Questioning, Trying, Reasoning, and Communicating) in the learning process can make students actively involved in constructing concepts, principles and laws (Maulina, Puspita, & Usman , 2018; Sukiminiandari, Budi, & Supriyati, 2015). The stages of learning with scientific approach include five stages, namely observing, asking, gathering information, associating, and communicating (Fitriani & Rohayati, 2019). Scientific approach can increase HOTS. Interactive design in e-books with scientific approaches such as experimental simulations, interactive videos, animated phenomena, can significantly increase students' HOTS by 67% at a 95% confidence level (Suyatna, Ertikanto, Herlina, & Pradana, 2019). In addition, the scientific approach also improves problem solving skills systematically, improves learning outcomes, helps communicate ideas and develops students' character (Prihadi, 2014).

The acquisition of student learning outcomes increases after carrying out physics learning using a scientific approach (Diani, 2016; Hardianti, Nurhayati, & Yani, 2015). Learning outcomes are the transition of behavior into learning outcomes in a broader sense covering the cognitive, affective and psychomotor fields (Sudjana, 2009). The success of the learning activities carried out by the teacher and the level of achievement of students in the competencies or materials that have been determined can be measured by learning outcomes (Kunandar, 2014). Through learning outcomes, teachers can reflect and evaluate the quality of learning that has been implemented. The methods, models, strategies, and media used by the teacher during appropriate and effective learning can be known through the learning outcomes of students.

The use of interactive e-books can improve student learning outcomes (Asrowi, Hadaya, & Hanif, 2019; Astuti, Siswandari, & Th, 2017; Pramana & Dewi, 2014). Previous research has developed an e-book with a scientific approach. E-books with a scientific approach are developed based on tourist attractions such as e-

books with a scientific approach to the Minang Silokek geopark (Rifai & Ummah, 2021), Padang beach (Rifai & Elvisa, 2021), Bukik Chinangkiek edupark (Rifai & Lestari, 2021), and Gadang houses (Sadraini & Rifai, 2021). In addition, interactive e-books with a scientific approach can improve higher-order thinking skills (Suyatna et al., 2019), improve science process skills (Rahayu, Astra, & Sugihartono, 2019) and improve student learning outcomes (Muamar, Retnoningsih, & Anggraito, 2021).

Based on some of the explanations above, the researcher will develop an Android-based physics e-book with a scientific approach. The physics e-book was developed using the iSpring Suite software and then converted into .apk form using Website 2 APK Builder. Physics e-books can be used offline on android smartphones. The physics e-book is developed according to the syntax of scientific approach. Several components in the physics e-book consist of cover, menu page, introduction page, user manual, material, evaluation, bibliography, glossary, and profile. The physics material in the e-book is impulse and momentum. Each sub-material in the e-book is presented with animations, pictures, and is equipped with sample questions. The evaluation menu consists of 10 multiple-choice questions with

answers and discussion. The learning outcomes of class X students on impulse and momentum materials are expected to increase through the application of physics e-book.

This study develops physics teaching materials in the form of an Android-based physics e-book with a scientific approach. The product is used as an independent teaching material for students on impulse and momentum material. This research was carried out with the aim of developing, knowing the feasibility of a physics e-book based on expert consideration and the effectiveness of a physics e-book to improve student learning outcomes on impulse and momentum material.

METHOD

The research is a development research or R&D. The development of physics e-books using 4D models according to Thiagarajan, Semmel, & Semmel (1974). The stages of the 4D model include the define, design, development, and dissemination stages. This research and development is carried out until the dissemination stage. The stages of 4D research and development are shown in Figure 1.

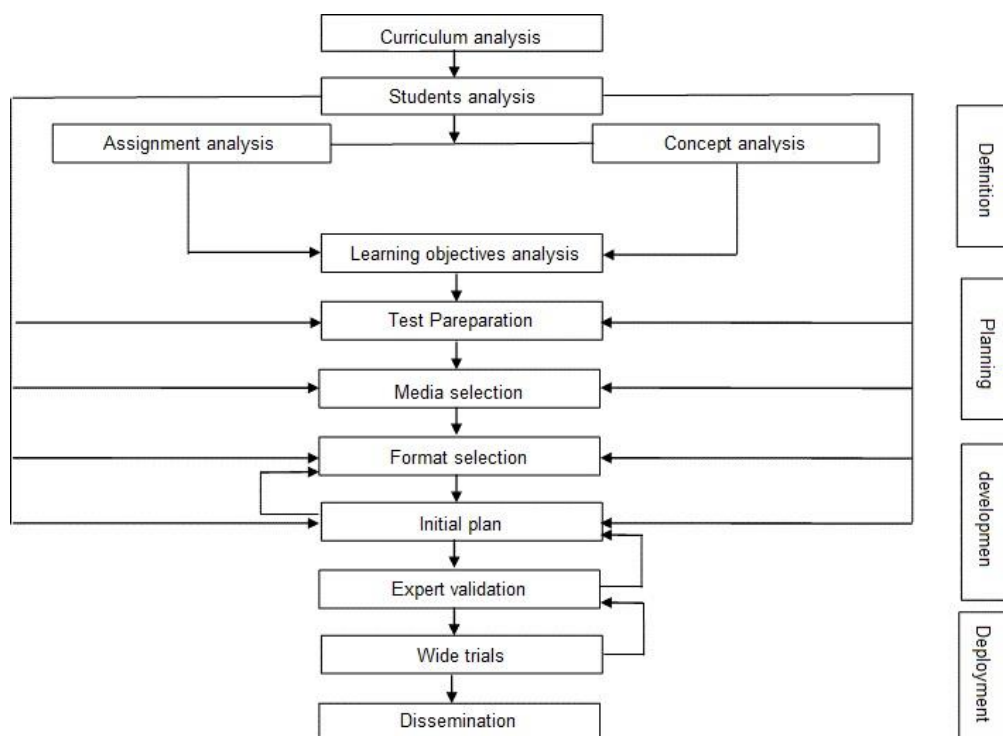


Figure 1. Stages of the 4D Model

The definition stage includes four activities, namely: (a) Curriculum analysis with the aim of understanding the characteristics of the curriculum applied in schools. At this stage, the researcher examines the core competencies, basic competencies, indicators and main materials developed. (b) Student analysis is carried out with the aim of identifying the characteristics of students, namely age, level of cognitive development and student abilities. (c) Task analysis is carried out with the aim of identifying what tasks are carried out by students during learning activities on impulse and momentum material with an Android-based physics e-book with a scientific approach. (c) Concept analysis is carried out with the aim of identifying physics concepts in physics e-books. This concept analysis includes the study of facts, concepts, principles, laws, theories as well as impulse and momentum concept maps. (d) Analysis of learning objectives is carried out with the aim of formulating learning objectives that refer to core competencies and basic competencies of the physics material used.

Design stage carried out with the aim of developing an Android-based physics e-book with a scientific approach to impulse and momentum material. This stage includes four stages, namely: (a) The preparation of the test in the form of an initial test (pretest) and a final test (posttest) is prepared referring to the material of impulse and momentum. (b) Selection of media, namely android-based physics e-books with a scientific approach that suits the needs and characteristics of students. (c) The selection of the physics e-book format and lesson plans is adjusted to the syntax/ learning stages of the scientific approach. The structure of the physics e-book consists of: (1) Introduction page (Core competencies and basic competencies, & Indicators, Learning Objectives, Concept Map); (2) Instructions for Use; (3) Material (Concept and Example Questions); (4) Evaluation; (5) Bibliography; (6) Glossary; (7) Developer Profile. (d) The format for preparing the physics e-book is used as the basis for the initial design of the physics e-book .

The development stage was conducted with the aim of producing an android-based

physics e-book product with a scientific approach. The product results were then validated by the physics teacher. The development stage consists of: (a) Expert validation in the form of a physics teacher's assessment of an Android-based physics e-book product with a scientific approach that has been developed. This assessment aims to provide input, suggestions, and comments on the material and appearance of the physics e-book. In addition, the physics teacher also assessed the accuracy of the test instruments through validation sheets. (b) Extensive trials were carried out on 34 students in class X MIPA 4 (Science major) at 1 Jatinom Senior High School. This stage aims to apply the revised physics e-book to students.

The dissemination stage is the stage where the product is disseminated for the benefit of others. In the research and development of physics e-books, the distribution is limited to physics teachers at 1 Jatinom Senior High School. In addition, research results are published scientifically.

The subjects of this study include validators, namely physics teacher at Warta Bakti Kefamenanu Catholic Private High School, physics teacher at SMA N 1 Jatinom (Senior High School), and 34 students in class X MIPA 4 (Science major) at SMA N 1 Jatinom. Subjects in the study were selected randomly by using probability sampling technique.

The design of this research is One Group Pretest-Posttest. Before doing the treatment, students were given a pretest, then given treatment in the form of learning physics with an Android-based physics e-book with a scientific approach. At the end of the lesson, students are given a posttest. Physics learning with an Android-based physics e-book with a scientific approach was carried out for four meetings.

Data collection techniques in the form of observation, questionnaires, and tests. The data collection instruments used were physics e-book validation sheets, test instrument validation sheets, and essay questions about impulse and momentum. The validation sheet is used to determine the feasibility of physics e-books and test instruments. The description questions are

used as a tool to measure students' understanding of the material impulse and momentum.

Expert validation sheets related to the product developed, namely an Android-based physics e-book with a scientific approach were analyzed descriptively. The first step is to tabulate all the scores obtained from the assessment items for each component. The score results are then analyzed by calculating the average answer given by the validator on each score using Equation 1.

$$\bar{X} = \sum \frac{x_i}{n} \tag{1}$$

The average results that have been obtained are then converted to a scale of 4 (Mardapi, 2012). First, find the ideal mean = (\bar{X}_i) and the ideal standard deviation (SB_i) with the provisions in Equation 2 and Equation 3.

$$\bar{X}_i = \frac{1}{2}(X_{maksimum} + X_{minimum}) \tag{2}$$

$$SB_i = \frac{1}{6}(X_{maksimum} - X_{minimum}) \tag{3}$$

Second, converting scores into values with assessment criteria such as Table 1.

Table 1. Criteria for Rating Scale Four

Score	Categorization
$X \geq \bar{X} + 1.0SB_x$	Very high
$\bar{X} + 1.0SB_x > X \geq \bar{X}$	High
$\bar{X} > X \geq \bar{X} - 1.0SB_x$	Low
$X < \bar{X} - 1.0SB_x$	Very low

The results of the quantitative scores were then converted into qualitative categories as shown in Table 2 (Mardapi, 2012).

Table 2. Conversion of Quantitative Scores into Qualitative Categories of E-book Validation Results

Score	Categorization
X 3.00	Very high
3.00 > X 2.50	High
2.50 > X 2.00	Low
X < 2.00	Very low

Physics e-book with a scientific approach to impulse and momentum material is included in

the good criteria if the results of the comparison of the validator scores with the above categorization are included in the high and very high categories.

The effectiveness of an Android-based physics e-book with a scientific approach is seen from the results of the students' pretest and posttest. The pretest and posttest questions were validated before being given to students. Validation was carried out by two physics teachers. The results of the validation of the pretest and posttest questions were analyzed using the V Aiken index. The data from the pretest and posttest were tested for normality using the Shapiro-Wilk test.

Then proceed with the Wilcoxon signed rank test to find out differences in student learning outcomes. The increase in student learning outcomes was analyzed using the N-Gain equation. The category of improving learning outcomes based on N-Gain is shown in Table 3.

Table 3. Categorization of N-Gain

Score	Categorization
$<g> > 0.70$	High
$0.70 > <g> > 0.30$	Medium
$<g> < 0.30$	Low
$<g> > 0.70$	High

RESULTS AND DISCUSSION

The results of the development are explained based on the development procedure. The define stage consists of curriculum analysis, student analysis, task analysis, concept analysis, and analysis of learning objectives. The revised 2013 curriculum has been implemented in physics

teaching and learning activities in secondary schools (Himawan & Ariswan, 2021; Rahayu & Kuswanto, 2020; Wirjawan, Pratama, Pratihina, Wijaya, Untung, & Herwinarso, 2020). One of the schools that implements the revised 2013 curriculum is SMA N 1 Jatinom (Senior high school). Physics teachers use power point media to explain physics material (Syarlisjiswan, Sukarmin, & Wahyuningsih, 2021).

The results of the analysis of students to determine the character of students in class X MIPA 4 (Science major) SMA N 1 Jatinom during the physics learning process took place. Student behavior during the teaching and learning process took place, namely only a few students responded to questions from the teacher (Priyanto & Kock, 2021). Most students prefer to be silent so that students are less actively involved in the learning process (Putri & Nur, 2022). Students only rely on the explanations given by the teacher, but some students are quite active during learning. When asked questions by the teacher, students respond and work on sample questions with the teacher. Asking questions is part of the learning process (Chung, Subramaniam, & Dass, 2020). However, most students respond to questions when their names are called by the teacher. Students also lack the initiative to ask questions to the teacher (Siswati, Umar, & Supartin, 2022). Meanwhile, this activity includes the task of students to establish communication by participating more in learning (Alawamleh, Al-Twait, & Al-Saht, 2020).

Concept analysis produces a concept map. The concept map made refers to core competencies and basic competencies for material used in physics e-books. Impulse and momentum material in the concept map includes the concepts of impulse, momentum, impulse-momentum theorem, law of linear momentum provision

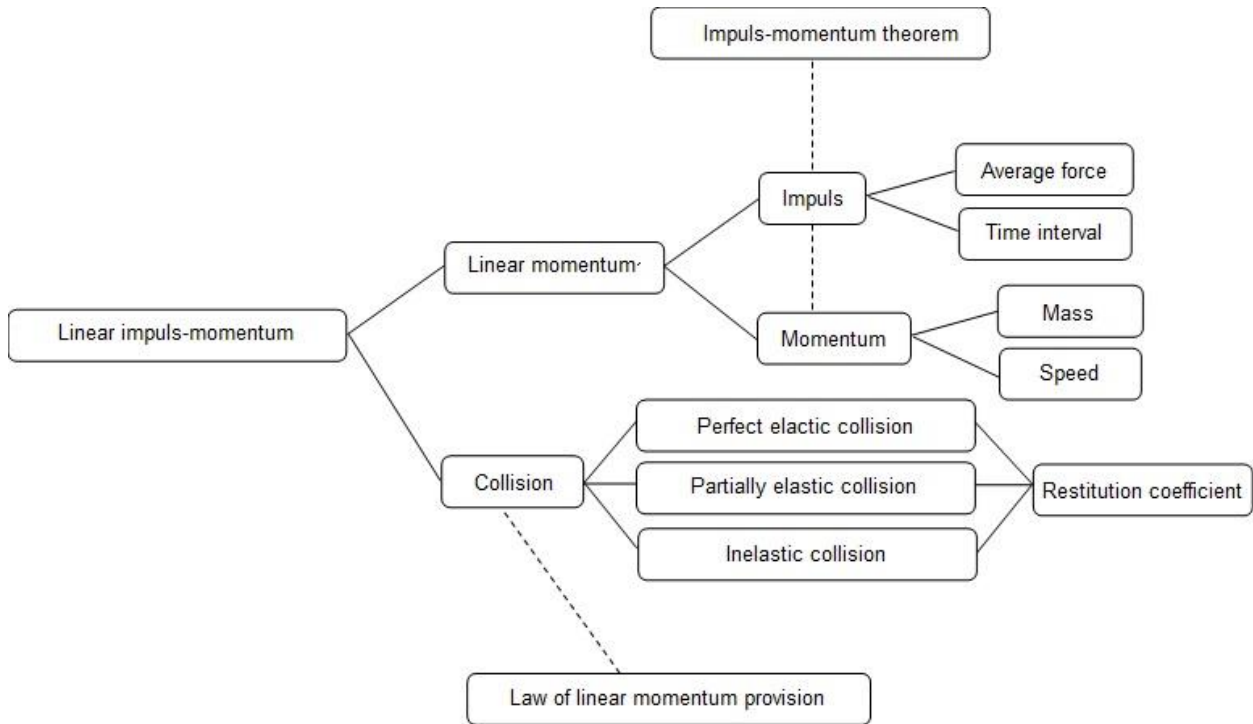


Figure 2. Concept Map

The average force acting on an object in a short time interval is the impulse. Impulse is also a change in momentum. Momentum occurs in collision events. For every collision, the law of linear momentum provision applies. Every object that collides has a coefficient of restitution. Based on the coefficient of restitution, collisions are divided into three, namely perfect elastic collisions, partially elastic collisions, and inelastic collisions. The concepts of impulse and momentum are related to everyday life. The application of the concept of impulse in everyday life is air bags and seat belts in cars, and boxing gloves. While the application of the law of linear momentum provision is the launch of rockets and guns.

The results of learning objectives analysis is students will be able to explain the concepts of impulse and momentum through learning using physics e-books with examples of questions and evaluation questions. Based on the results of analysis at the define stage, it is necessary to develop an Android-based physics e-book with a scientific approach on impulse and momentum material. The presentation of physics e-books uses

electronic devices, namely smartphones so that students are easy to access anywhere and anytime. Physics e-books are equipped with pictures and animations that match the material described, making it easier for students to understand the concepts of impulse and momentum.

The design stage produces an Android-based physics e-book with a scientific approach so that it can be used as teaching material for class X students, especially on impulse and momentum material. The physics e-book was developed referring to the needs and characteristics of students. The physics e-book was developed using the iSpring Suite 10 software. At the *design stage*, the researcher designed the e-book format and test instrument.

Physics e-book format adapted to the learning syntax of a scientific approach. The stages of learning the scientific approach include five stages, namely observing, asking, gathering information, associating, and communicating. The physics e-book format consists of an introduction page, user manual, materials, evaluation,

bibliography, glossary and developer profile. On the introductory page there are core competencies, basic competencies, indicators, learning objectives, and concept maps. The core competencies in e-books refer to the four core competencies that have been defined in the 2013 curriculum. The development of e-books refers to impulse and momentum materials.

Impulse and momentum material includes the concept of impulse, momentum, impulse-momentum theorem, the law of linear momentum provision, types of collisions and the application of impulse and momentum in everyday life. Impulse and momentum material is presented in detail with equations, sample questions in each impulse and momentum material subsection, and evaluation questions to make it easier for students to understand the material. There are three tasks carried out by students in the physics e-book, namely tasks in scientific learning, assignments in sample questions and assignments in evaluation questions. Example questions in the form of a description question for each submaterial. The evaluation questions consist of 10 multiple choice questions from each impulse and momentum submaterial which are done independently by students. Evaluation questions can be directly corrected and there is a solution in the physics e-book.

The physics learning process was carried out in four meetings with an allocation of 3 hours of lessons (3 x 30 minutes). The first meeting, gave pretest and explanation of impulse material, the second meeting, gave momentum and impulse-momentum theorem explanation, the third meeting, gave the law of linear momentum provision and types of collisions, and the fourth meeting, gave explanation about the application of impulse and momentum in everyday life and gave posttest. Learning activities carried out by students are in accordance with the stages of scientific approach. At the observing stage,

students observed the animation of impulse and momentum material events presented in the physics e-book. Students will collect facts from the observed animation and then use it in the next stage. In the questioning stage, students were guided to ask questions from the observed events. Students and teachers asked questions to each other related to the events observed. In the stage of gathering information, students carry out group discussions. Students were asked to read e-books or search for information on the internet. Associating stage, the teacher guides students to make conclusions from the results of the discussion and answer questions in the physics e-book. In the communicating stage, students present the results of the discussion. Each group appoints a representative to present the results of the discussion.

The test instrument that has been prepared is five questions about *impulse and momentum* material descriptions. The test was distributed to students before and after being given treatment, namely learning physics with an Android-based physics e-book with a scientific approach. The initial design of this physics e-book was draft I. Draft I was validated at the development stage to determine the feasibility of the product being developed.

The development phase consists of expert validation, revision, and extensive testing. Expert validation includes e-book validation and test instrument validation. The broad trial is the implementation of physics learning with an Android-based physics e-book with a scientific approach.

Draft 1 of the physics e-book was validated by experts to get input, suggestions, and comments. Draft 1 of the physics e-book made includes cover, menu page, introduction page, user manual, materials, evaluation, bibliography, glossary, and profile. The results of the developed draft are shown in Figure 3.



(a)



(b)

Figure 3. E-Book display (a) cover (b) menu

Validation of the physics e-book expert was carried out by a physics teacher at SMA N 1 Jatinom. The aspects of the expert assessment are the feasibility of the material/content, language and images, the design of the e-book content, and the language. The average score of the validation results based on the Likert scale is 3.40 and belongs to the very high category. This means that the product developed is feasible to be applied in physics learning on impulse and momentum material.

Draft 1 of the physics e-book did not provide sample questions for each sub-chapter and there was only an evaluation question at the end of the material. So, the input from the expert was to add sample questions for all subsections of impulse and momentum material. Then revisions were made according to the results of expert validation before extensive trials were conducted . The results of the revision according to expert advice and input become draft II which will then be tested on students of class X MIPA 4 SMA N 1 Jatinom.

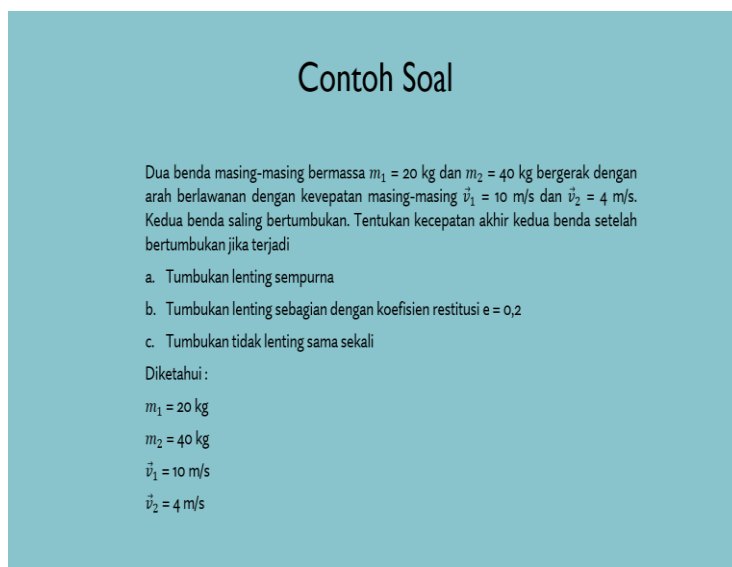


Figure 4. The appearance of the e-book after revision

The impulse and momentum test instruments are validated by two validators. Validation is carried out with the aim of assessing the feasibility of the test instrument given to

Table 4. Validation Results of Pretest and Posttest Questions

Items	V Aiken	Category
1	0.83	Very Valid
2	1.00	Very Valid
3	1.00	Very Valid
4	1.00	Very Valid
5	1.00	Very Valid

Based on Table 4, all question items are in the very valid category. The questions were revised according to the input and suggestions given by the validator. The results of the revision were then implemented to 34 students in class X MIPA 4 at SMA N 1 Jatinom. If the development stage has been completed, the physics e-book product developed can be declared suitable for use in physics learning activities.

The revised physics e-book was then given to 34 students of class X MIPA 4 at SMA N 1

students. The results of the instrument validation are shown in Table 5.

Table 5. Normality Test Results of Learning Outcome Data Jatinom. Data from extensive trial results will be used to determine the effectiveness of the physics e-book on student learning outcomes.

The effectiveness of the physics e-book on impulse and momentum material is seen from the results of the students' pretest and posttest. The pretest and posttest data came from 34 research samples. The data from the pretest and posttest were tested for normality using the Shapiro-Wilk test. The results of the normality analysis of the pretest and posttest data are shown in Table 5.

Table 5. Normality of Pretest and Posttest Data

Learning outcomes	df	Asymp.Sig. (2-tailed)
<i>Pretest</i>	34.00	0.58
<i>Posttest</i>	34.00	0.41

Based on Table 5, the data on student learning outcomes before and after using the physics e-book were normally distributed with Asymp.Sig. (2-tailed) > 0.05 (Ituningsih, Baedhowi, & Sangka ,

2018). Then, further hypothesis testing was conducted using the Wilcoxon signed rank test.

Wilcoxon signed rank test to determine differences in student learning outcomes before and after using the e-book physics. The results of the Wilcoxon signed rank test analysis are shown in Table 6.

Table 6. Results of Wilcoxon signed rank test analysis

Learning outcomes	Average	Minimum	Maximum	Asymp.Sig. (2-tailed)
<i>Pretest</i>	42.00	15.00	65.00	
<i>Posttest</i>	76.68	60.00	100.00	0.00

Based on Table 6, the average pretest of students is 42.00 with a minimum and maximum score of 15.00 and 60.00. The average posttest of students is 76.68 with a minimum and maximum score of 65.00 and 100.00. Based on the average gain, student learning outcomes increased after the implementation of physics learning using an Android-based physics e-book with a scientific approach. Asymp.Sig value . (2-tailed) obtained is 0.00, so there are differences in student learning outcomes (Adawiyah, Susilawati, & Anwar , 2020). Thus, there is an effect of using physics e-books on student learning outcomes. The increase in learning outcomes of students in class X MIPA 4 was analyzed using the N-Gain equation. The N-Gain value obtained is 0.59 which is included in the medium category (Hake, 1998). Thus, learning physics with an Android-based physics e-book effectively improves the learning outcomes of students in class X MIPA 4 at SMA N 1 Jatinom (Hediansah & Surjono, 2019).

The learning process affects student learning outcomes. Learning outcomes are abilities possessed by students after students receive knowledge in the learning process (Astuti et al., 2017) . The results of this study found that an Android-based physics e-book with a scientific approach could improve student learning outcomes. This is supported by the research of Hardianti et al., (2015) which found that learning

with a scientific approach can improve students' physics learning outcomes. In addition, learning physics using an Android-based e-book with a scientific approach can improve students' conceptual understanding (Wulandari et al., 2019).

The physics learning process at SMA N 1 Jatinom is carried out online during the pandemic. Teaching and learning activities are carried out on a limited basis by utilizing Google Meet. Teachers and students often experience a lack of time to get optimal learning outcomes (Sari et al., 2022).

Therefore, physics e-books can support the learning process. Impulse and momentum material is presented in the form of text, images and animations. This supports students to be able to construct their knowledge and visualize material so that it makes it easier for students to understand the concepts of impulse and momentum (Pahlawan, Ismet, & Syarifuddin, 2021). The use of smartphone - based e-books equipped with videos and pictures can improve student learning outcomes (Asrowi et al., 2019; Hasbiyati et al., 2019).

E-book is equipped with a menu of evaluation questions that aim to train students' depth of knowledge on impulse and momentum material. The evaluation questions consist of 10 multiple choice questions. Students answer the questions provided and find out the score obtained. The evaluation menu is also equipped with a discussion of each question.

The learning process using interactive e-books supports students in obtaining better learning outcomes than learning using printed books (Suyatna, District, Herlina, Suyanto, & Haryaningtias, 2018). Android-based e-books trigger an interactive and independent learning environment between students and students and also with teachers, because students' enthusiasm for learning tends to be high (Hediansah & Surjono, 2019). Students who are enthusiastic about learning will support the improvement of their learning outcomes.

Draft of the physics e-book that has been applied in a wide trial will be disseminated at the dissemination stage. Deployment stage is the final stage in the 4D model. An Android-based physics

e-book with a scientific approach is limited to physics teachers at SMA N 1 Jatinom. In addition, research results will be published scientifically.

CONCLUSION

The product developed is an Android-based physics e-book with a scientific approach to impulse and momentum material for class X high school students. Based on expert judgment, the feasibility of the product is in the very high category, which is 3.40. The effectiveness of the physics e-book in terms of the students' pretest and posttest results. The Asymp.Sig value (2-tailed) obtained is 0.00. The increase in learning outcomes of students in class X MIPA 4 is included in the medium category with the N-Gain value obtained is 0.59. An Android-based physics e-book with a scientific approach can be used by teachers to improve student learning outcomes on impulse and momentum material. The physics e-book developed has several shortcomings, such as not presenting videos in explaining impulse and momentum material, there is only one example problem for each sub-material, and the physics e-book is only developed on one physics material. Thus, it is hoped that further researchers can develop an Android-based physics e-book with a scientific approach to other physics materials. In addition, the explanation of the material in the physics e-book can be equipped with a video and include more than one example question.

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