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Physics E-book with Augmented Reality to Improve Students' Interest in Physics

Ria Riski Novita[1*]

[1]Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

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ABSTRAK

Pada abad ke-21, ilmu pengetahuan dan teknologi menjadi faktor penting dalam pendidikan untuk mendukung guru dan siswa dalam mengakses sumber belajar dengan mudah. Penelitian ini bertujuan untuk mengembangkan e-book fisika dengan augmented reality di PBL dan untuk mengetahui efektivitas fisika e-book dengan augmented reality di PBL untuk meningkatkan minat mahasiswa. Metode penelitian menggunakan jenis penelitian Research and Development (R&D) dengan model 4D yaitu Define, Design, Develop, dan Disseminate. Subjek uji coba produk terbatas terdiri atas 30 peserta didik, sedangkan subjek uji coba produk luas terdiri atas 105 peserta didik. Teknik pemilihan sampel menggunakan teknik random sampling. Hasil penelitian menunjukkan bahwa e-book fisika dengan augmented reality pada materi suhu dan kalor sangat layak digunakan dalam pembelajaran berdasarkan penilaian oleh para ahli dalam aspek media dan materi serta layak digunakan berdasarkan respon siswa. Pemanfaatan e-book fisika berbantuan augmented reality dalam pembelajaran menunjukkan bahwa minat belajar fisika siswa pada kelas eksperimen lebih baik dibandingkan kelas kontrol 1 dan kontrol 2. Hal ini menunjukkan bahwa pemanfaatan e-book fisika berbantuan augmented reality yang menarik mampu menarik minat belajar sehingga siswa lebih aktif dalam pembelajaran.

ABSTRACT

In the 21st century, science and technology are becoming important factors in education to support teachers and students in accessing learning resources easily. This study aims to develop physics e-books with augmented reality in PBL and to determine the effectiveness of e-book physics with augmented reality in PBL to increase student interest. The research method uses the type of Research and Development (R&D) research with 4D models, namely Define, Design, Develop, and Disseminate. The subjects of the limited product trial consisted of 30 students, while the subjects of the broad product trial consisted of 105 students. Sample selection technique using random sampling technique. The results showed that physics e-books with augmented reality on temperature and heat materials are very feasible to be used in learning based on assessments by experts in media and material aspects and are suitable for use based on student responses. The use of augmented reality-assisted physics e-books in learning shows that students' interest in learning physics in experimental classes is better than control class 1 and control 2. This shows that the use of interesting augmented reality-assisted physics e-books is able to attract interest in learning so that students are more active in learning.

1. INTRODUCTION

Physics is a scientific discipline that studies natural phenomena that occur in daily life. Physics learning emphasizes providing direct experience to develop student competence. One of the aspects that influence a person to achieve goals is interest. Students' interest in learning physics is generally less in demand, because it is considered difficult, this results in learning physics not meeting expectations (Multazam, 2020; Yuliana et al., 2021). Students' interest in learning is needed to help optimize student learning outcomes. Students who have interests, students will have desires that are accompanied by attention and activeness that cause students to feel happy about changes in behavior both in the form of knowledge, attitudes and skills (Ikbal et al., 2021; Maison et al., 2020). Based on the results of interviews

*Corresponding author
E-mail addresses: riski88@gmail.com (Ria Riski Novita)

with students, it shows that students have difficulty in understanding physics concepts because according to students in learning physics too many formulas are understood. This causes students' interest in learning physics to be relatively low. One of the factors that influence this is the presentation of material that is less varied and tends to be monotonous, which is related to the readiness of teachers in the implementation of learning in the classroom (Mardiana & Kuswanto, 2017; Rusdin, 2018). Students' interest in learning physics is generally less in demand, because it is considered difficult, this results in learning physics not as expected (Dou et al., 2018; Multazam, 2020). A person's interest cannot appear suddenly. Interest can grow if you have experience. Students are able to save something they learn in the long term if the learner has an interest in it so that they are able to relate it to existing knowledge. Previous study state teachers can facilitate learners in efforts to increase interest in learning by: 1) providing opportunities for students to discuss with teachers; 2) form study groups; 3) redirects to learning content and content creation tools; 4) Using the app to design and implement active learning strategies (Irawaty et al., 2021).

In the 21st century, science and technology are important factors in education. Teachers can utilize digital media in knowledge development to attract the attention and interest of learners (Chu et al., 2021; Degner et al., 2022). The use of technology in education can help students improve higher-order thinking skills. Students are expected to have innovation skills, as well as abilities and knowledge in technology, media, and information (Fitriani, 2014; Wijaya et al., 2016). Technology can be used by teachers to prepare interactive learning media. Learning media is a tool to convey messages from sources to recipients that can support the learning process. Learning media can innovate with the development of science, especially in the field of physics. One form of learning media is an electronic book (Saraswati et al., 2018; Wardani & Mundilarto, 2021). E-books are characterized by color images, animations, simulations, and videos. Current technological developments support teachers and students to access learning resources easily. Currently, printed books have been replaced by electronic books which are more interactive and varied. This causes learning activities to be more fun with various learning strategies that are relevant to teaching topic and student characteristics (Liliana et al., 2020; Wardani & Mundilarto, 2021). Electronic books offer students, teachers, and schools complementary media to support or enhance the learning process (Alkadri & Fauzi, 2021; Astuti et al., 2017). Augmented Reality (AR) is a form of using technology in education. Augmented reality is a technique of rendering virtual objects on real images captured through a camera and giving a different sense of reality from virtual reality (Sung et al., 2019; Vagg et al., 2020). The characteristics of AR technology can turn abstract learning into content and concepts into dynamic content that is lively and understandable (Cai et al., 2021; Suprapto et al., 2020). Learning physics with augmented reality is more realistic and can develop students' skills and improve the ability of science laboratories and conceptual understanding (Amelia et al., 2020; Bakri et al., 2019).

Through AR learning becomes more real and not monotonous, and can assist students to understand and analyze the problems found in learning In addition to learning media, the model or approach used in the learning process also has an influence on the sustainability of teaching and learning activities. Previous study state problem based learning was conceived and applied more than five decades ago, and is considered one of the most innovative pedagogy to improve the competence of learners (Hidayati et al., 2020). Problem-based learning (PBL) presents various problems that occur in the surrounding environment so that it can stimulate them to learn. In PBL, learning is student-centered, so that students actively seek information on their own and determine which information to learn to help them in learning. PBL is student-centered to conduct research, integrate theory and practice, and utilize knowledge and skills in the development of appropriate solutions to a problem (Mundilarto & Ismoyo, 2017; Tawfik, 2015).

Based on the description, learning e-books as teaching materials are very important to improve students' interest in learning physics. Physics is a scientific discipline that studies natural phenomena that occur in daily life. Physics learning emphasizes providing direct experience to develop student competence (Multazam, 2020; Yuliana et al., 2021). Students' interest in learning physics is generally less in demand, because it is considered difficult, this results in learning physics not meeting expectations. Students' interest in learning is needed to help optimize student learning outcomes (Kwarikunda et al., 2020; Maison et al., 2020). Students who have interests, students will have desires that are accompanied by attention and activeness that cause students to feel happy about changes in behavior both in the form of knowledge, attitudes and skills (Ikbal et al., 2021; Wahyuni et al., 2020). This has resulted in researchers want to develop an Augmented Reality-assisted learning e-book that can be used in learning activities, so that it is more varied so that students are not bored when carrying out learning activities.

2. METHOD

The type of research for the development of e-books assisted by augmented reality is Research and Development (R&D), which is the process for developing and validating product (Borg & Gall, 1983). The development model used is 4D, namely Define, Design, Develop, and Disseminate (Thiagarajan, 1974). The purpose of this study was to develop physics e-book with augmented reality in heat and temperature topic. This research was conducted in April 2022 at public senior high school of Ngabang in 11th grade of science program. The purpose of this study was to develop physics e-book with augmented reality in PBL and to know effectiveness physics e-book with augmented reality in PBL to improve students' interest.

The define stage is definition of development needs, included curriculum analysis, student analysis, and concept analysis are carried out. At the design stage, determine the topic, the learning goals, and the instrument that will be used in this research. The development stage includes the eligibility assessment of the product, and product trials. The indicators of the feasibility of the product shown in Table 1.

Table 1. Indicators of The Feasibility of the Product

The Feasibility of the product based on	Aspect	Indicators
Matter Expert	Learning	The suitability of the material presented in *the e-book* with the core competencies
		The suitability of the material presented in *the e-book* with basic competencies
		Conformity of competency achievement indicators with basic competencies
		Conformity of indicators with learning materials
		Conformity of learning objectives to learning indicators
		Clarity of study instructions on the material
		Clarity of images/animations/videos used to assist learners in understanding the material
	Material	The correctness of the concept of temperature and heat matter
		Collapse of the presentation of temperature and heat material
		The accuracy of the use of communicative and easy-to-understand language
		The accuracy of the use of equations and symbols on the material in *the e-book*
		Compatibility of the question with the answer key
		The suitability of text, images, animations, and videos with temperature and heat materials
		Compatibility of the examples given in the *e-book* with the material
Media Expert	Audio Visual	Completeness Of Identity Which Includes The Application Title, Developer Profile, And Institution Logo (Uny)
	Display	Layout *proportion fit*
		Conformity of color proportions
		Background selection suitability
		Letter selection suitability
		Button display consistency
		Clarity of instructions for use of *the e-book*
	Software Engineering	Ease of accessing *the e-book* app
		Creativity and Innovation
		The compatibility of *e-books* with the development of science and technology

The design of this study was a pretest-posttest control group design. The trial design is shown in Table 1. Where X1 was a pretest for the experimental class, X2 was a pretest for the 1st control class, X3 was a pretest for the 2nd control class, T1 was learning by using physics e-books with augmented reality in PBL, T2 was learning using textbook media, T3 was learning using pdf e-books, Y1 was a posttest for the experimental class, Y2 was a posttest for the 1st control class, and Y3 was a posttest for the 2nd control class. Data collection technique is non-test assess eligibility of e-book and questionaire of students'

interest in physics. The indicators of students' interest include feelings of pleasure, concentration of attention, participation, interest, preparation in learning, and students' knowledge of the benefits of learning. The data from eligibility assessed by several aspects are namely audio visual display software engineering, learning component, and material component. The results were analyzed using descriptive analysis, which is using the average score on each aspect. The mean score on each aspect of the evaluation was converted to score criteria as shown in Table 2.

Table 2. Classification of Eligibility Score

No.	Interval Score	Category
1.	$X \geq X_i + 1{,}8\ SB_i$	Very Good
2.	$X_i + 0{,}6\ SB_i < X \leq X_i + 1{,}8\ SB_i$	Good
3.	$X_i - 0{,}6\ SB_i < X \leq X_i + 0{,}6\ SB_i$	Quite Good
4.	$X_i - 1{,}8\ SBi < X \leq X_i - 0{,}6\ SB_i$	Less Good
5.	$X \leq X_i - 1{,}8\ SB_i$	Very Less Good

The effectiveness test was carried out using the Anova Mixed Design test with the General Linear Model (GLM). Analysis using GLM to test whether there are differences in the pretest-posttest scores of students' interest in each group.

3. RESULT AND DISCUSSION

Result

The results of the analysis found at the defined stage are that the use of technology in learning has not been given optimally. The use of smartphones is not allowed by the school because it avoids abuse during learning. However, this is not an obstacle because the school provides a tablet that can be used by students when learning at school. The learning materials used are temperature and heat. KI and KD are used from the 2013 curriculum. KD is used to formulate GPA and learning objectives to improve students' HOTS. HOTS assessment is the ability to analyze and evaluate. The design stage was carried out to design an augmented reality-assisted physics e-book product. Systematically designing augmented reality-assisted physics e-books was preceded by compiling development guidelines, flowcharts, and storyboards. The components of an augmented reality-assisted physics e-book include several components, namely homepage, foreword, menu list, contents, reference, and developer profile. The content component consists of several sub-components, namely introduction, material, student discussion sheets, and quizzes. The components of the augmented reality-assisted physics e-book consist of three parts, namely the opening, the content, and the closing. The opening section of the augmented reality-assisted physics e-book includes the augmented reality-assisted physics e-book title and the logo of Universitas Negeri Yogakarta. The content section includes introduction, materials, augmented reality, LDPD, and quizzes. The concluding section includes developer references and profiles. The feasibility assessment of augmented reality-assisted e-books is reviewed based on media and material aspects. Table 3 shows the results of the feasibility assessment by expert and students.

Table 3. The Result of Feasibility Assessment of Augmented Reality Assisted Physics E-book

Assessment Augmented Reality Assisted Physics E-book by Expert		
Rated Aspect	**Score**	**Category**
Audio Visual Display	97.78	Very Feasible
Software engineering	92.75	Very Feasible
Learning	96.43	Very Feasible
Material	96.00	Very Feasible
Average	**95.74**	**Very Feasible**
Assessment Augmented Reality Assisted Physics E-book by Students		
Rated Aspect	**Score**	**Category**
Contents	84.28	Feasible
Presentation	80.44	Feasible
Graphics	81.68	Feasible
Language	84.17	Feasible
Average	**82.64**	**Feasible**

Base on Table 3, the analysis activities showed that physics e-book with augmented reality in heat and temperature topic are categorized as very feasible. The product was tested on 30 students at SMAN 01 Ngabang. Students are asked to use an augmented reality-assisted physics e-book, then students are asked to fill out a questionnaire on student responses to the use of e-book augmented reality assisted physics. The product developed is an augmented reality-assisted physics e-book in the form of an application that can be accessed using an Android smartphone with an .apk extension format. The e-book application developed contains various competencies that will be achieved during learning, concept maps, temperature and heat materials, sample questions, practice questions, and student discussion sheets. On the student discussion sheet, there are questions then students can upload the answer. Referring to the table of the validity coefficient of aiken the minimum value received is 0.83 for 8 raters with an error rate of 1%. The results of the aiken validity analysis showed that the value of the Aiken validation coefficient on each of the statement items was in the range of 0.92 to 0.96. So that the conclusion was reached that all points of the statement of interest in learning physics are valid based on the aspects of the content.

After eligibility assessment and validity activities, an extensive trial was then carried out. The extensive trial aims to see whether there are differences in the results of students' interest in learning physics using the-e-book augmented reality-assisted physics, when compared to conventional learning that is usually done by teachers. The results of the posttest of students' interest in learning physics shown in the Figure 1.

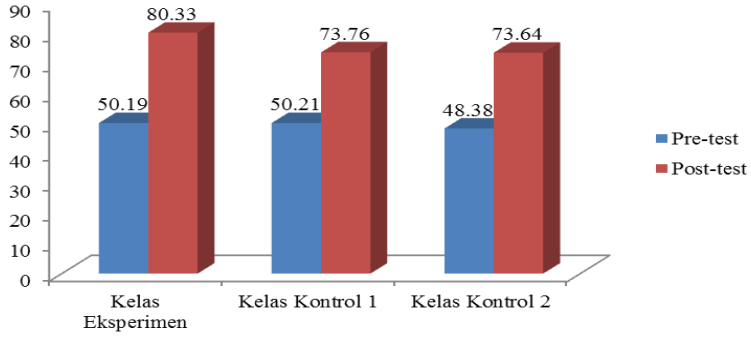

Figure 1. The Average Score of Students' Interest in Physics

Base on Figure 1, describe that there is an increase in students' interest in learning physics. The increase in interest in learning physics occurred in the experimental and control classes, but the experimental class has a greater increase compared to the control class. Significant differences in the variables of interest in learning between classes can be identified by conducting the Post-Hoc test. The test results can be obtained in the Bonferroni type multiple comparison test, which is presented in Table 4.

Table 4. The Result of Pairwase Comparisons

Variable	Class	(I) Time	(II) Time	Mean Differe-nce (I-J)	Sig.
Students' Interest in Physics	Experiment	Pretest	Posttest	-30.143	0.000
	Control 1	Pretest	Posttest	-23.548	0.000
	Control 2	Pretest	Posttest	-25.262	0.000

Based on Table 4, information was obtained that the significance value of students' interest in learning physics was less than 0.05. These results showed that there was a significant increase in the variables of interest in learning physics of students in each class. A negative Mean Difference value indicates that the posttest value obtained by each class is higher than the pretest value. Thus, it can be concluded that the treatment given in the experimental class with learning using augmented reality-assisted physics e-books on the PBL model is more effective in increasing students' interest in learning physics compared to the treatment given in control classes 1 and 2. The Result of Post-Hoc Multiple Comparisons Bonferroni Type is show in Table 5.

Table 5. The Result of Post-Hoc Multiple Comparisons Bonferroni Type

Variable	(I) Time	(J) Time	Mean Difference (I-J)	Sig.
Students' Interest in Physics	**Exsperiment**	*Control 1*	3.27	0.000
		Control 2	4.25	0.000
	Control 1	*Exsperiment*	-3.27	0.000
		Control 2	0.98	0.351
	Control 2	*Exsperiment*	-4.25	0.000
		Control 1	-0.98	0.351

Table 5 shows that the significance value of students' interest in learning physics in the experimental class against control class 1 and control 2 is less than 0.05. However, the significance value of interest in learning physics in the 1st and control 2nd classes is greater than 0.05. This means that the interest in learning physics in the experimental class differs significantly from that of control classes 1 and 2. Meanwhile, there was no significant difference in interest in learning physics in control class 1 and control 2. The amount of contribution obtained from physics learning activities in each class with different treatments is presented in the following hotelling's trace type multivariate test Table 6.

Table 6. The Result of Multivarite Test of Hottelings' Trace Type

Variabel	Kelas	F	Sig.	Partial Eta Squared
Students' Interest in Physics	Eksperimen	1130.618	0.000	0.917
	Kontrol 1	689.987	0.000	0.871
	Kontrol 2	794.114	0.000	0.886

Table 6 obtained information on the partial eta squared value of students' interest in learning physics in the experimental class was greater than that of control class 1 and control 2, which was 0.917. It shows that the increase in interest in learning physics of students in the experimental class was 91.7% greater than that of control class 1, which was 87.1% and control was 2 88.6%.

Discussion

The use of technology in education has a positive impact on the learning processThe integration of technology in learning becomes a means to improve learning and student engagement (Alkadri & Fauzi, 2021; Jeffri & Awang Rambli, 2021). The development of teaching materials is carried out to provide innovative teaching materials in supporting the physics learning process. The teaching materials developed are augmented reality-assisted physics e-books that can be operated using android-based smartphones. Augmented reality presented in the e-book is in the form of animations that visualize the application of temperature and heat in everyday life. Augmented reality-assisted physics e-books include front pages, foreword, menu lists, introductions, learning materials, augmented reality, learner discussion sheets, HOTS quizzes, reference lists, and developer profiles. The development of augmented reality-assisted physics e-books is carried out by paying attention to audio-visual display, software engineering, materials, and learning. Learning with AR is more effective in developing understanding of the material and assisting students in finding information relevant to the material (Martín-Gutiérrez et al., 2017; Radu & Schneider, 2019). This shows that AR can assist students in overcoming their shortcomings in understanding physics concepts and interest students in learning electrical concepts (Ritter, 2012; Ropawandi et al., 2022).

Augmented reality-assisted physics e-books are assessed by expert lecturers, physics teachers, and peers. This assessment aims to determine the feasibility of augmented reality-assisted physics e-books before a limited test is carried out. The assessment results show that augmented reality-assisted physics e-books are very feasible to use in limited tests with an average value of 95.26 based on media aspects and 96.22 based on material aspects. Furthermore, a limited trial was carried out which aimed to determine the feasibility of augmented reality-assisted physics e-books from student assessments. The feasibility assessment is carried out using a student response questionnaire. The assessment results show that augmented reality-assisted physics e-books are in the category worthy of use in physics learning with an average score of 82.64. Physics learning by utilizing physics e-books assisted by augmented reality is effective in increasing students' interest in learning physics. The experimental class experienced a greater improvement compared to the contrast class. Learning using augmented reality-assisted physics e-books

can help students to utilize technology in learning so that it can attract students' learning interest. The presentation of animation in the form of augmented reality brings a new experience to students so that they are more interested in being active in learning physics. Technology in education can influence students to learn actively and motivate learning (Saidin et al., 2015; Yuberti et al., 2021). The use of e-books in physics learning is effective in helping to increase students' interest in learning and students' activity (Aisyah et al., 2020; Suprapto et al., 2021) The use of augmented reality can improve student learning outcomes by helping to provide visualizations to make it easier for students to understand the material provided. Students and teachers respond positively to physics laboratory based Augmented Reality and it shows that there is an increase in understanding of physics concepts in students (Amelia et al., 2020; Del Cerro Velázquez & Méndez, 2021).

The use of augmented reality-assisted physics e-books in learning using PBL also has an influence in learning activities. The results of this study show that the use of physics e-books in learning temperature and heat materials can affect students' interest in learning physics. Students' interest in learning in experimental classes is better compared to comparison classes. The increase is due to a more interesting form of learning resources that integrate technology in learning. The PBL model allows students to find and solve problems (Mundilarto & Ismoyo, 2017; Nuswowati et al., 2017). PBL in this learning is used to help students solve problems presented in the student's work sheet which is carried out in groups. The cognitive level honed in this activity is the ability of students to analyze and evaluate the phenomena presented. This is in line with other studies that explain that PBL is an effective learning model in improving student learning achievement (Argaw et al., 2017). The application of PBL in learning can train students' ability to solve problems (Hidaayatullaah et al., 2020; Rahayu et al., 2019).

The relevance between previous research and this research is the use of teaching materials in the form of e-books, the use of PBL learning models with augmented reality. However, there is a difference in this study, namely the development of augmented reality-assisted physics e-books, what distinguishes this e-book from the research is that e-books and augmented reality exist in one application equipped with learning materials, student discussion sheets, and quizzes. In previous research, AR was used as a virtual laboratory learning medium. In e-books, augmented reality is used to provide visualization so that in the e-book there is an augmented reality menu. It aims to help increase students' interest in learning physics. In this study AR is used to assist students in analyzing events that occur in the real world related to temperature and heat material. Implication of this study increased engagement by Physics e-books with augmented reality can increase students' interest in physics by making the learning experience more engaging and interactive. AR technology can bring abstract concepts to life and provide students with a visual and interactive way to explore and understand the subject. The use of AR in physics e-books can also help students understand complex topics by providing visual representations of abstract concepts, which can help students connect the theory with the practical applications. The limitation of this regarding to AR technology is still relatively new, and technical difficulties with the software or hardware could negatively impact the learning experience. The effectiveness of AR technology in physics e-books will depend on the quality of the content and how it is integrated into the curriculum. If not properly implemented, it may not lead to the desired outcomes in terms of improving students' interest in physics.

4. CONCLUSION

Augmented reality-assisted physics e-books are very feasible for use in learning based on assessments by experts. The results of the assessment for the media aspect in the very feasible category and the material aspect in the very feasible category. An augmented reality-assisted physics e-book is feasible to use in learning based on student responses in the feasible category. Augmented reality-assisted physics e-books can increase students' interest in learning better than learning in control classes. The use of augmented reality-assisted physics e-books is able to attract students' interest in learning which results in students participating more actively and training students in utilizing technology in learning. This can help students in realizing technology-based learning so that students can access learning materials without being limited by space and time.

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