Development of physics learning modules in supporting the implementation of digitalization education wave material based on Augmented Reality (AR) and Physics Education Technology (PhET)

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Abstract

The era of the industrial revolution 4.0 and 5.0 is the era of digitalization, the era in which the man who drives the development of the country's economy has been slowly replaced by mechanical automation and digitization of technology. The role of science and technology is necessary for the success of the digitalized era of education. Technology-based modules are essential to digitizing education and avoiding loos learning. The technology that can be used to digitize education is using three-dimensional images using augmented reality technology integrated using PhET (Physic Education Technology). The research aims to implement Augmented Reality (AR) and Physics Education Technology (PhET) in the development of physical modules for enterprise materials and renewable energy. This module will be about materials and renewable energy which contains barcodes that when scanned using a student's smartphone, then will appear a real three-dimensional picture. While business practicums and renewable energy will emerge in the form of links that will later be connected to PhET and students can simulate experiments on energy change, enterprise and renewed energy. The research method uses the ADDIE development model, namely analysis, design, development, implementation and evaluation. The research was carried out at Kesatrian 2 Semarang High School involving 50 students and 2 specialists. PhET-based and Augmented Reality learning modules applied to the experimental class can help students to improve their problem-solving skills. an evaluation of the applications already implemented in the school, which assessed the effectiveness of the use of AR and PhET learning modules on vibrational and wave material. Effectiveness can be reviewed from the response of students who have used the reviewed module from the level of comprehension of the material. The effectiveness score reaches 83%, which means that the module is developed effectively to support the process of learning activities in the classroom.

Keywords : augmented reality; PhET; digitalization of education

INTRODUCTION

The era of the industrial revolution 4.0 and 5.0 is the era of digitalization, the era in which the human beings that drive the development of the economy of the country have been slowly replaced by mechanical automation and digitization of technology. The role of science and technology is necessary for the success of the digitalized era of education. Because knowledge and science and technology are essential, the world of education must also be able to keep up with these technological developments. (Herman, 2023). Physics is one of the subjects that requires a lot of media to convey or explain material and of course practicum. Not only are the formulas studied in physics, but real events are imperative. Students' lack of understanding of science is illustrated by a survey by the Programme of International Student Assessment (PISA) which shows that in 2018 in the field of science, 35% of Indonesian students were still in the competence group of level 1a and 17% at the lower level. (McComas, 2014). The non-interactive learning modules and the still-hindered practical processes make the learning objectives unattainable.

Technology-based modules are essential to digitizing education and avoiding loos learning. The technology that can be used to digitize education is by using three-dimensional images using augmented reality technology integrated with PhET (Physic Education Technology). Augmented reality (AR) is an information delivery medium that is evolving, is a technology that integrates two dimensional or three dimensional virtual objects into the real environment around us (Hartono, 2019). Teaching learning activities require learning media that can connect, inform and disseminate messages for an efficient teaching learning process, learning media which corresponds to the development of the era of the industrial revolution one of which is augmented reality (Inayah, 2022). Looking at the capabilities of AR, it can be used as an exciting learning medium and advance technology (Siahaan, Medriati, 2019). Augmented reality provides an experience for users to interact with virtual content in the real world (Rachmi, 2022), so it can be more attractive because objects can be seen in 3D and have a very significant impact in their applications that require visual functions (Rizaludin, 2022). Created an augmented reality system application on the student worksheet achieved success and works well on smartphone use so that the application can be used in the learning process (Sumardani, 2020). The advantages of augmented reality, among other things, if applied in learning media will make learning more active between teachers and students, its use is more effective when compared to other media, the objects displayed are simpler, cost-effective and easy to use (Riska Dewi dan Anggaryani, 2020). PhET is an interactive simulation of physical phenomena, based on research given free of charge and improving the learning outcomes of high school students (Subiki, 2022)

PhET is a simulation of physics, chemistry, geoscience biology and mathematics. This site provides free learning simulations to download in the interests of classroom learning or self-study (Zainudin, 2017). PhET is a learning software from the University of Colorado. Research on PhET virtual labs where students are invited to provide the response that exists in the virtual lab, then computers will respond and provide feedback can improve students' cognitive abilities. (Sadikin dan Hamidah, 2020). Application of eLearning development assisted by PhET virtual laboratory can improve student learning performance (Agustine, Wiyono, Muslim 2014)

Three technological innovations that will change the world include 5G networks, augmented reality and artificial intelligence. Augmented reality (AR) is an emerging medium of information delivery, a technology that integrates two- and three-dimensional virtual objects into the real environment around us (Hartono, 2019). Looking at the capabilities of AR, it can be used as an exciting learning medium and advance technology. Augmented reality provides an experience for users to interact with virtual content

in the real world (Rachmi, 2022), so it can be more attractive because objects can be seen in 3D and have a very significant impact in their applications that require visual functions (Rizaludin, 2022)

AR applications on smartphones are very diverse, including Google AR services, merge explorer, wenoopa, quiver and asemblr edu. The easiest to apply is google AR, by way of opening google then type the name of the animal and find the 3D image writing and click the room buttons and the smartphone tab then the animal will go out to our real room.

Implementation of the practice is not only done in the laboratory or in the field, but with very rapid technological advances, then the practice can be carried out in the virtual laboratory (Kadir dan Keguruan 2014). A virtual laboratory is a program that contains a laboratory tool that works just like a real tool. Students are invited to provide a response to a virtual lab, then the computer will respond and provide immediate feedback to the user in the form of an instruction program (Sadikin dan Hamidah, 2020).

The web-based virtual lab display format can help students to conduct their internships independently. Virtual Laboratory categorized into 5 (Gunawan, Harjono, dan Sahidu 2017) That's:
1. Classical simulation that contains the elements of a specific laboratory experiment and is available there (simulation).
2. Classic simulation which contains elements of certain laboratory experiments and is accessible online (cyber laboratory).
3. Simulation that tries to present a laboratory test that is as compatible as possible with a real experiment (virtual lab).
4. Simulation laboratory that conducts experiments using virtual reality techniques (VR lab).
5. Real experiment controlled via a network or the Internet (internet lab).

Physics practice is a compulsory thing to do, with technological advances of many applications that can be used to replace practicum in person. Some applications can use video tracker analysis, science edu and PhET. PhET is an interactive simulation of physical phenomena, based on research provided for free. PhET is a simulation of physics, chemistry, geoscience biology and mathematics. This site provides free learning simulations to download in the interests of classroom learning or self-learning. PhET is a learning software from the University of Colorado. The simulation provided is highly interactive that invites learners to explore in person. Measurements are also available in this simulation, such as a grid, a stopwatch, a voltmeter and a thermometer. This PhET simulation, in addition to being used online, can also be used offline. Provided that the computer has Java and Flash programs.

METHODS

The method used in AR and PhET implementation research in this learning module is the development research method with the ADDIE model (Analysis, Design, Develop, Implementation, Evaluation).

The stage of the analysis is to analyze the needs used to identify the needs of teachers and students during the learning process of teaching, in accordance with the independent curriculum and digitalization of education. The survey will be conducted with a live interview of 10 students and teachers from Kesatrian 2 Semarang High School. From this analysis, a solution will be created that will help solve the required needs, namely the creation of modules based on augmented reality (AR) and physics education technology (PhET). The design of the research method as shown in Figure 3.1. The designed module will be named AR-PhET EBT. This phase will require the preparation of the Assemblr Edu

software that will be used to create 3D objects, animations and visual effects that can be accessed by anyone integrated with the PhET web. The research method looks like Figure 1.
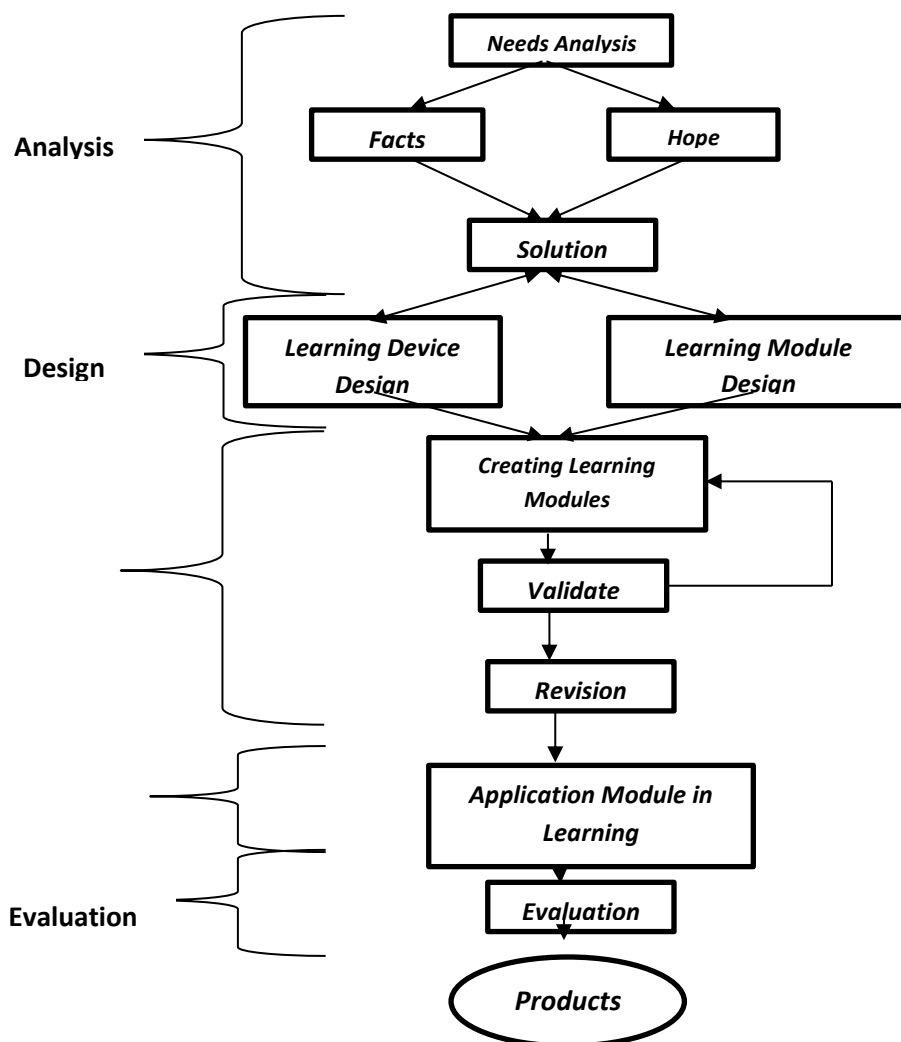

Figure 1. Research methods

RESULTS AND DISCUSSION

The results of the quality validation of the module by the media and material experts obtained that from the learning design aspects and materials received averaged = 3.75 or in the category well. The software engineering aspects at the initial validation stage of the validator stated a decent but needed slight revision on the audio settings, the final validation phase after the revision received an average = 3.5 (good category).

From the lift filled by the students at the stage of the limited trial, the findings were that there were experimental links using PhET that could not be used, because the computer or laptop facilities used did not support media or modules. After at the test stage and analyzed then obtained the result that the average quality of the learning module = 3,59 or in the good category, while the result of the lift filled teacher obtains an average score = 3,88 or in good category. The result of the development of this module and research is the first phase, the media is made revised according to the advice of the media and material experts. The media revisions are made mainly on the link for simulations of practicums that

cannot be opened or not supported by facilities in all laptops or students' hp.

The second stage, the media is validated by the media and material experts. The result is that the learning media that exists in the module especially for Augmented Reality is still less rapid in opening, so it still takes a lot of time to be able to generate the vibration and wave display in its original form.

The third stage, the media tested on a small group obtained results that the modules used for independent learning students can help in understanding about matter vibration and waves, because within the module displayed a simulation link practicum that students can try independently. It also displays virtual content that can interact with the real world, so students can see a real picture of vibrations and waves and their applications in everyday life.

The fourth stage, modules tested in large groups (experimental classes), obtained results that the module is said to be effective in assisting the learning process for vibration and wave matter. PhET-based learning modules and Augmented Reality that are applied to experimental classes can help students to improve their critical thinking skills. If seen from critical thinking indicators on experimental classes on pre-test and post-test can be seen improvements in Table 1.

Table 1. Critical Thinking Indicator Percentage

	Analyzing Questions	Identifying Assumptions	Determining the Solution and Writing the Answer	Make a Conclusion	Determining Other Ways in Settlement
Pre test	65,1%	54,9%	14,2%	8,46%	0%
Post test	100%	99,5%	76,8%	82,8%	57,2%

Of the five indicators used in the assessment of critical thinking proved to be on there is an improvement of the pre test and post test. Indicators that determine other ways of solving problems are still low, the correct answer score is only 57.2%. The indicator analyzes questions, identifies assumptions, determines solutions and writes answers and makes high conclusions. PhET-based and Augmented Reality learning modules applied to experimental classes can help students to improve their problem-solving skills. an evaluation of the applications already implemented in the school, which assessed the effectiveness of the use of AR and PhET learning modules on vibrational and wave material. Effectiveness can be reviewed from the response of students who have used the module reviewed at the level of understanding of the material. The effectiveness score reaches 83%, which means that modules are developed effectively to support the process of learning activities in the classroom.

CONCLUSION

Based on the objectives and results of research, it was concluded that the physics modules have been developed to support the digitization of education, and the development of physical learning modules by implementing Augmented Reality and Physic Education Technology can improve the effectiveness of teaching learning processes.

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