Augmented Reality on Special Rays of Lens; Design and Validity

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Abstract. One of the efforts in changing the education system for the better is the application of learning media that supports the era of RI 4.0. Physics subjects have an important role in facing the Industrial Revolution 4.0, namely providing opportunities for students to explore knowledge through technology that suits their needs, one of the sources of technology that can be used by students is Augmented Reality (AR) technology. The purpose of the study was to design and test the validity of AR which was applied to the special rays of the lens material. The resulting product is named special rays of the lens-based Augmented Reality (SILAR). The development model used in this research is a 4-D development model (four-D Model) with the stages of Define, Design, Development, and Dissemination. The data collection technique used in this study was an assessment instrument with a questionnaire. There are 4 questionnaire assessment instruments, namely material validation questionnaires whose results are in the good category (89%), media validation questionnaires with an average of 90% (good), question validation questionnaires in the good category (89.5%).

Keywords: Augmented Reality, Special Rays of the Lens.

1 Introduction

Currently, the world has entered the era of the industrial revolution which is marked by increased connectivity and interaction as well as the development of digital, artificial intelligence, and virtual systems. As the boundaries between humans, machines, and other resources are becoming more and more unified, information and communication technology undoubtedly has an impact on various areas of life. One of them is the impact on the education system in Indonesia [1]. The desired education system in the era of the industrial revolution 4.0 is an education system that can bring a better human civilization [2], [3].

One of the efforts in changing the education system for the better is the application of learning media that supports the era of RI 4.0. This situation requires teachers to upgrade their facilities and competencies in dealing with millennial 4.0 education, including those related to ability and creativity in utilizing learning media [4], [5]. Learning materials from various easily accessible sources will assist educators in planning and implementing learning in the classroom. The

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application of learning by collaborating face-to-face learning with distance learning can increase students' learning time. Especially in physics subjects which are often considered difficult by students, which causes low interest in learning physics subjects [6], [7].

Physics is a science that studies natural events that are physical in nature and can be studied through experimental or observational activities. Physics can be studied through observation, experimentation, and theory, the results of which can be used as facts, concepts, principles, and laws.[8]–[10]. Physics subjects have an important role in facing the Industrial Revolution 4.0 which is to provide opportunities for students to explore knowledge through technology that suits their needs, one of the sources of technology that can be used by students is Augmented Reality technology [11], [12].

Augmented Reality is an interactive media technology that continues to develop, offers additional interactivity to real-world objects, and can provide information directly through digital applications [13], [14]. This technology may sound new to some people. In general, this technology application is developed on a desktop PC, but as technology advances, many applications adopt Augmented Reality technology into a smartphone application [15]. In this era of the Industrial Revolution 4.0, smartphones are not only used for some of these functions, but smartphones can also be used as media in the learning process [16]. The development of smartphones has attracted the world of education, and can be used as a learning aid technology [17].

The smartphone functions as a place to install applications in the form of an apk, so the smartphone will be used as a medium for producing three-dimensional visuals known as AR. The name of the application developed in this research is SILAR (Special Rays of Lenses Based on Augmented Reality). The reason for choosing Special Rays Lenses in the material to be applied in AR media is that according to observations made in general physics courses on the subject of optics, there are still many students who are confused in distinguishing between special rays on both lenses (convex and concave) and the difference between special rays of mirrors and lenses.

There is a very significant difference in students' knowledge of Lens material in the Physics Department with students who are not in the Physics Department. The first reason that students who are not majoring in Physics have very little knowledge about Lenses is that they are not interested, for example from the 21A Computer Science Education class, which amounts to 34 people, only 7% are active in lecture activities. The second reason is that the media is too conventional, especially for the last two years, learning has been carried out online (online) so it requires lecturers to always innovate in learning media.

Based on the problems faced, innovative solutions are needed, especially in the manufacture and application of learning media according to the era of R.I 4.0. The media offered to overcome students' understanding of Optical Materials, especially in the sub-material of Lens Special Ray, is to apply Augmented Reality-based learning media.

2 Methods

The development model that will be used in this research is the 4-D development model by Thiagarajan and Semmel in 1974 [18] with the stages of implementation consisting of: Define, Design, Development, and Dissemination [19]. The data collection technique used in this study was an assessment instrument with a questionnaire. There will be 4 questionnaire assessment

instruments, namely material validation questionnaires, media validation questionnaires, question validation questionnaires, and student response questionnaires. Questionnaire grid developed based on the formative evaluation instrument for teaching materials published by the Ministry of National Education in 2008.

Data analysis techniques are carried out to obtain good quality products that meet the aspects of validity, practicality and effectiveness. Data were obtained through expert validation, student response questionnaires, and test for the effectiveness of learning media with AR technology.

3 Result and Discussion

3.1 Defining Stage

The definition stage is the stage to determine and formulate learning requirements. This phase is almost the same as the analysis phase in other development models. Through an analysis of the objectives and problems of the existing media or learning tools. There are five steps that are usually carried out in the define stage, namely to determine and define the requirements needed in learning which include:

Early-Late Analysis. In the early and final stages, it is carried out in general physics courses outside the Department of Physics to explore problem information. The method used in data collection is direct observation with the result that students are less interested in attending general physics lectures because they tend to be calculated and the media applied is still conventional. Viewed from the material side, the Optical Material in the Lens sub-material is a weakness for students because they cannot clearly distinguish the difference between the special rays of Lens. Therefore, researchers provide a solution, namely the development of learning media with augmented reality technology.

Student Analysis. The student analysis phase is carried out to determine the attitude or character of students in the learning process. The students analyzed were those who had received a General Physics course that was not a Physics Department. Observation results show that understanding of physics concepts is still low due to low student interest in physics courses and the average student conveys that he is not interested in the learning media given because it has often been applied to high school, there should be a change because it is already at the University. Then, learning media with AR technology was developed to improve understanding of physics concepts in the material of special rays of the lens.

Material analysis. Based on observations in general physics courses, the Lens material is one of the materials where students have very low knowledge.

Task analysis. Students are directed to work independently on problems, so that students can solve problems individually assisted by learning media that are already available. Assignments are given so that students are able to find the concept of the special rays of the lens. Furthermore, students are expected to be able to apply the concepts they learn to solve problems related to the special rays of the lens. In accordance with the learning indicators, the task given is about the description of the special rays of the lens and how to solve them using the formula.

Specification of learning objectives. The specifications of the learning objectives are for reference in developing learning media with AR technology. The objectives of the learning are; 1) Students can describe the special rays of a convex lens and a concave lens; 2) Students can

understand the concept of physics in the material of special rays of the lens; 3) Students can solve problems contained in the material of special rays of the lens.

3.2 Designing Stage

The purpose of the design stage is to design the learning media that will be made. There are three stages in the design stage, as follows: media selection, format selection, and initial design.

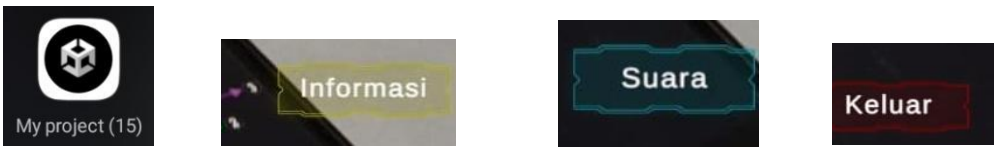
Media Selection. The basis for the selection of media development is based on the results of observations of the General Physics course in the Computer Science Class, namely that all students must have a smartphone as a source of communication and information, then students' interests must always be related to computers and the internet. Based on this information, the learning media developed is an android-based learning media with AR technology.

Format Selection. The selection of the format is carried out after determining the learning media to be developed, the selection of this format is adjusted to the needs of android-based learning media with the apk format. The learning media developed requires smartphone specifications with the Android operating system with a minimum type of Android 4.1 Jelly Bean.

Initial Design. The initial design needed in this development is hardware and software. The software needed in this development are Unity 3D, Blender, and Voforia Engine, while the hardware needed is a laptop and a webcam. Then system design requires user experience design and user interface design.

The user experience design uses a modeling language to facilitate the design process. The modeling language used is UML (Unified Modeling Language) diagrams. UML is a set of diagrams used to abstract a system or object-based software .

The design of the user interface design uses a storyboard with the aim of simplifying the design of the system flow and graphic design. Storyboards are created to assist the application design process. The application developed was named *SILAR* which is an acronym for *Sinar Istimewa Lensa Berbasis Augmented Reality*. Here's the storyboard design.



(a) (b) (c) (d)

Fig. 1. (a) SILAR app icon image; (b) Information page; (c) Sound page; (d) Exit Page

There are several stages in the design of the lens special AR application, as follows:

Hardware and Software. The hardware required is (a) a personal computer or laptop with a webcam, and (b) an Android smartphone. While the required software are; (a) Unity 3D, (b) Blender, (c) Adobe Illustrator, (d) Android Development Tools, and (e) Vuforia SDK.

3D Object Creation. Making 3D objects In making 3D objects, a software called Blender is used with version 2.79b. The 3D objects used in this research include (1) a special ray of a concave lens, and (2) a special ray of a convex lens.

Database Creation. The database in question is a marker database which will later be inserted into Unity 3D during application development. Marker is an image that will be detected by an augmented reality camera. However, not all images can be used as markers. The image that will be used as a marker must have a complex or unique pattern so that it is easy to read the AR system.

Scene Creation in Unity 3D. The developed application will be processed in Unity 3D software. Unity 3D is software for developing an application that also supports application development with the Android operating system and also supports making applications with AR technology. Each process in development in Unity 3D is limited to a scene that represents a single application page. In this application, several scenes are made which become pages in the SILAR application.

App Design. This stage is the implementation process of the design that has been made in the storyboard. This design process is done with Adobe Illustrator software. The designs made include the background, buttons and also 2 markers. The following is an application design presented in the following image:

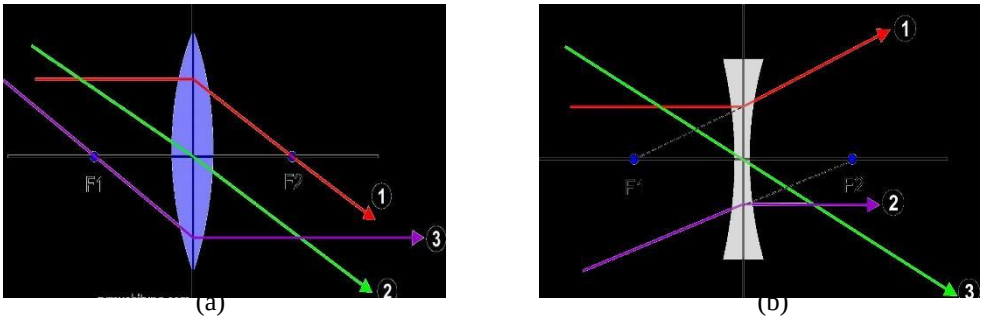


Fig. 2. (a) Convex Lens Marker, (b) Concave Lens Marker

Each marker provides an understanding and explanation of the special light material of the lens, as well as a 3D animation that can appear from the marker from the AR camera.

3.3 Development Stage

The development stage is the stage of realizing the design of the media and instruments used to measure the performance of the products that have been developed.

Media Expert Validation. Media testing includes aspects of language, aspects of font use, aspects of layout, aspects of illustrations and images, and aspects of display, which were carried out by two media experts Lecturers from the Department of Physics, Universitas Negeri Medan with 20 statements to be assessed, with the results of the data obtained as follows :

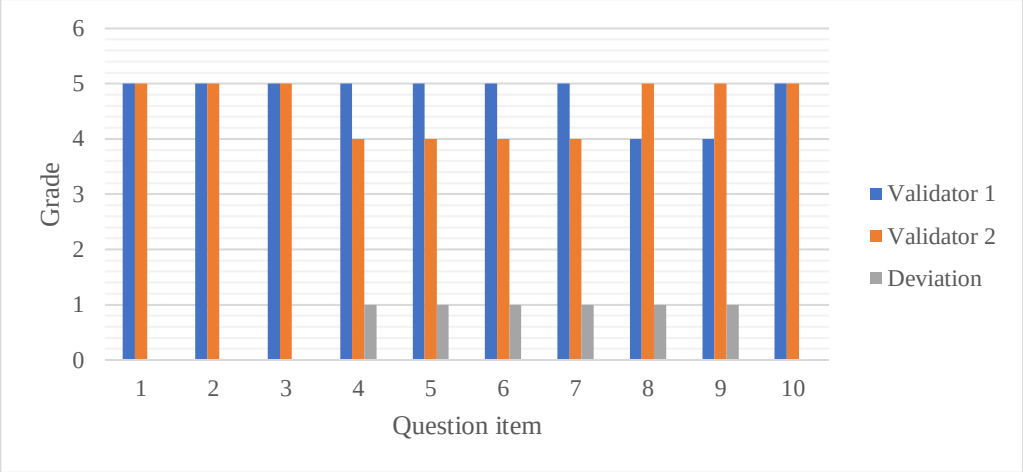


Fig. 3. Media Expert Test Results

Material Expert Validation. This expert assessment was carried out to determine the validity of the developed SILAR application. The SILAR application was validated by two material expert validators, Lecturers of the Department of Physics, Universitas Negeri Medan with 20 statement items and the following data were obtained:

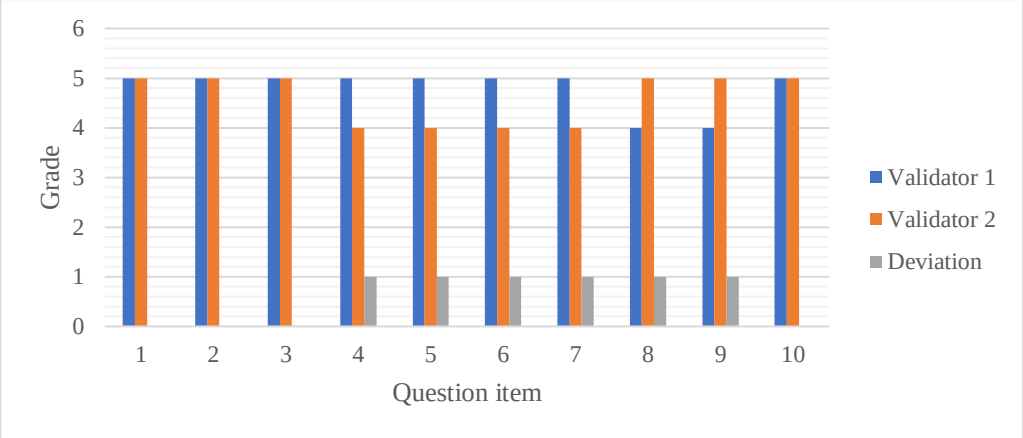


Fig. 4. Material Expert Test Results

Validation of Pretest And Posttest Questions. The ability test for understanding physics concepts consists of a pre-test and a post-test consisting of 10 multiple-choice questions. The first test is the pre-test. The pre-test was conducted to determine the students' initial ability to understand physics concepts on the lens special light material before learning activities were carried out. The second test is the post-test. The post-test was conducted to determine the students' conceptual understanding ability after learning using the developed SILAR application. The results of the pre-test and post-test were used to measure the effectiveness of using the SILAR application developed in learning. The test questions were carried out by two expert validators from the Department of Physics, Universitas Negeri Medan and the following data were obtained:

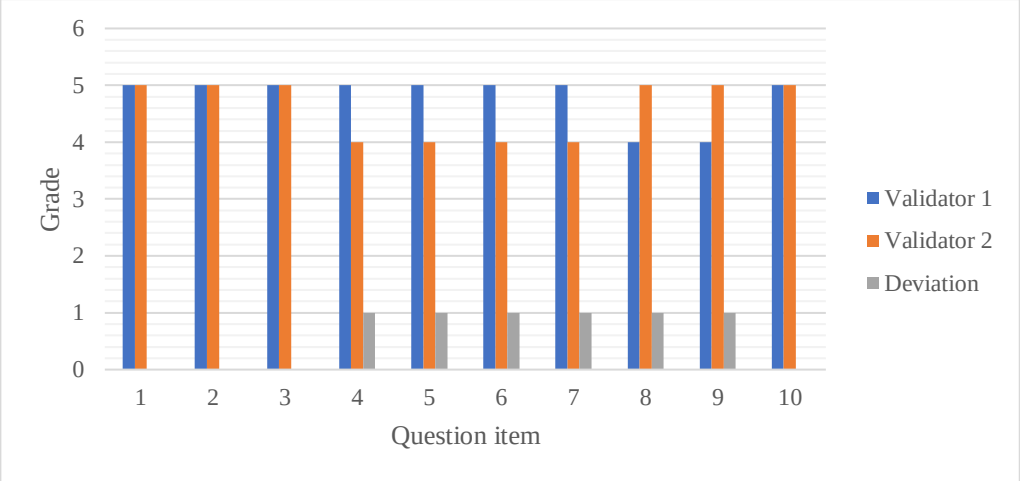


Fig. 5. Test Validation Results

4 Conclusion

The conclusion from the implementation of this research is that the SILAR application is still in the development stage and is already valid in terms of media and materials because it has been validated by experts.

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