Design of Basic Physics Practicum Module Using Augmented Reality

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Abstract. The Basic Physics practicum is one of the compulsory courses that supply psychomotor abilities related to physical experiments. Basic physics practicum modules are developed to help students complete basic physics practicum courses well. This research aims to develop the design of basic physics practicum modules assisted by augmented reality technology to make it easier for students to perform experimental procedures. This research uses qualitative descriptive methods. The results of the analysis of student needs showed that almost 85% of students agreed and needed AR media in the Physics 2 practicum module to facilitate the implementation of the practicum. The results of the module analysis show that the module is designed by presenting a very comprehensive description of the material. Technology innovations are needed that help visualize practicum tutorial videos. The innovation design of practicum modules developed based on the results of the analysis using augmented reality in the presentation of experimental procedures.

Keywords: basic physics practicum module · augmented reality

1 Introduction

The changing world is now entering the era of the industrial revolution 4.0 where information technology has become the basis of human life [1]. The industrial revolution 4.0 has changed the way people live and work. In its development, the 4.0 industrial revolution provides challenges as well as impacts for the younger generation and also the world of education in Indonesia. The development of the industrial revolution 4.0 appeared marked by the start of the digitalization of the education system which directs every element in the education sector to be able to make adjustments to the rate of change that occurs.

One of the uses of technology in education is the use of Augmented Reality technology in learning. Augmented reality (AR) is a technology that visually augments the real world environment by projecting computer-generated information into the eye [2]. AR is a rapidly growing field of research that aims to fully integrate the virtual with the real environment [3]. Thus AR can be interpreted that real objects in real time are added to

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virtual objects that appear when using tools or devices on the real object. So that there is a relationship between the virtual world and the real world with the help of the camera. The camera records what is in the real world and displays it on a computer or smartphone screen, with the help of a special marker, there will be an additional three-dimensional virtual display on the computer or smartphone screen [4].

Learning using electronic books and e-learning requires a device that must be connected to an internet connection, quite difficult to use if it is not connected to the internet. While augmented reality can be accessed via mobile phones that are not connected to the internet. The advantages of Augmented Reality are as follows: 1) More interactive, 2) Effective in use, 3) Can be widely implemented in various media, 4) Simple object modeling, because it only displays a few objects, 5) Making that does not take too much a lot of cost, 6) Easy to operate [4, 5]. The AR that will be developed is a video which contains applications in everyday life, concepts, explanations of experimental objectives, tools and materials, and experimental steps contained in the basic physics practicum II manual which is included in the Unity application, Vuforia SDK, and Android Studio, processed on a laptop and transferred to an Android smartphone. The (real) camera on the smartphone will visualize the video that was previously entered.

The Physics Practicum course is part of the mandatory courses at UT. Based on the results of field observations, it was found that many students had difficulties in completing this course due to the unavailability of a supplementary capable of helping to obtain visualization of practical procedures. UT learning activities that are closely related to the use of technology encourage them to be able to develop supplementary practicum courses so that they can run more optimally. This requires finding solutions and alternatives in using technology to support the implementation of physics practicum activities. In the physics practicum course, students are expected to have direct experience in carrying out physics practicum procedures. Obstacles in the field are difficulties for students in following experimental procedures due to the unavailability of media that visualizes it, causing difficulties for students and ineffective implementation of physics practicum.

The practicum that is currently taking place at UT is carried out at the partner laboratory of each registered student area. To assist and guide students in carrying out practicum activities, UT provides assistance in the form of practical video guidance in the form of a CD which is attached to each student practicum module. The use of CDs is certainly not optimal for now, considering that CDs are not portable objects and to use the CD requires an external device on a PC. CD also cannot be played on smartphone/android devices. This becomes an obstacle in the implementation of practical and effective practical and practical guidelines and guidelines. There should be a technological innovation that helps make it easier for students to access the guidance of practicum activities.

One technology that can be used to support and facilitate students to get a more real experience in practical activities is to use augmented reality technology [6]. This technology can bridge students to be able to participate in all practicum activities through real visuals [7]. Practical activities that are displayed through augmented reality technology are inserted in the supplementary in the form of a practicum guide. Supplementary in the form of videos can facilitate practicum activities and be a solution related to the

difficulties of students carrying out practicum [8]. Videos can guide students, making practicum activities more focused and achieving goals better than without using videos. [9–11]. This supplementary is expected to increase the number of students who can complete the physics practicum course well. The advantage of this supplementary in supporting physics practicum lectures is that it is practical to use. Augmented integrated supplements can be downloaded and used with applications that can be installed on Android phones. The aim of this research is:

1. To describe the Physics 2 practicum activities currently taking place at UT
2. Describe the results of the analysis of student needs in the Physics 2 practicum lecture
3. Describing the results of curriculum analysis in Physics 2 practical lectures
4. Describe the initial design of the AR technology-assisted practicum module

2 Method

This type of research is descriptive qualitative. This study aims to describe the initial design of the Physics 2 practicum module which was designed based on Augmented Reality technology. The need for AR technology in Physics 2 practicum is based on the results of student needs analysis and curriculum analysis. Respondents in this study were students, teachers and lecturers. This research was conducted during the years 2020–2021. In this study, to collect data used instruments in the form of questionnaires and observation sheets. Data analysis was carried out in a qualitative descriptive manner.

3 Result and Discussion

Physics Practicum 2 is one of the compulsory subjects taken by students in the Physics Education Study Program, FKIP UT. Practical activities are carried out directly at UT partner laboratories spread throughout Indonesia. The practicum material in the Physics 2 practicum course consists of 9 modules, each module consisting of 2 to 3 practicum activities. Practical activities can be held in 8 lecture sessions, and all follow the pattern set by UT.

3.1 Implementation of the Physics 2 Practicum that is Currently Taking Place at UT

Physics 2 practicum activities are held by collaboration between UT and partner campuses or schools that are willing to facilitate students in carrying out practical activities. In every practicum activity, students are required to document the practicum activities carried out and report the results of the practicum in each session. The type of practicum that is carried out is no longer the dry-lab concept, but is carried out directly and monitored through the Microsoft Teams application. Every practicum activity that is held, students are guided by an instructor and the course of practicum activities is monitored by lecturers from the Physics education study program. In the Physics 2 practicum course, an online platform is also provided, namely the Learning Management System (LMS). LMS display as in Fig. 1.

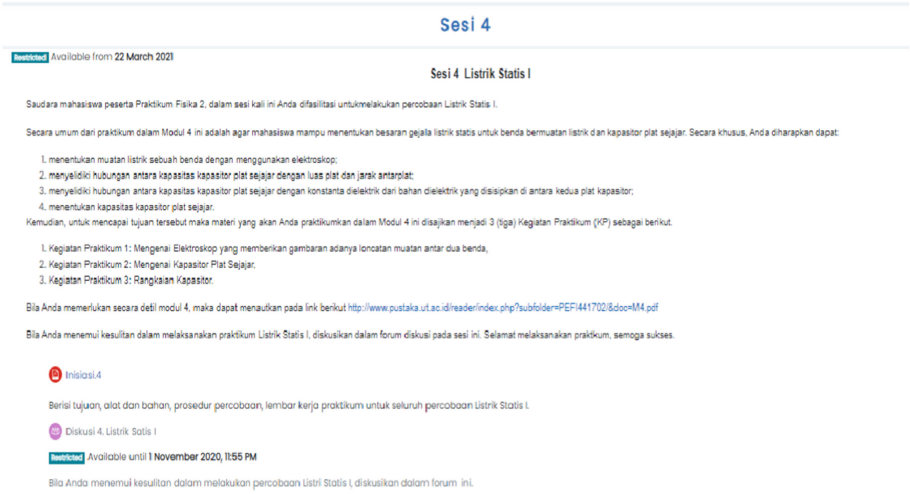

Fig. 1. Display of LMS in Physics Practicum Course 2

The use of LMS in Physics 2 practicum activities greatly facilitates students to participate in practicum activities. Technology can be used to help students carry out practical activities, technology can act as a medium and guide students to carry out practical activities [12–14]. In the LMS, there are several features that help students participate in Physics 2 practicum activities. One of the features is the availability of initiation material features, practicum guides and discussion features. The difference between discussion in LMS and e-learning lies in the topics discussed. In e-learning, there is a problem topic that will be discussed by all students, the tutor assesses the discussion and the value of the discussion contributes to the final grade of the student's online tutorial. In LMS, the discussion feature is used by students to discuss the obstacles encountered during the implementation of practicum activities. In the discussion feature, it is possible for students to also participate in discussions regarding the suitability of the results of practicum activities obtained with existing theories. Tutors actively provide feedback and provide solutions to problems encountered by students during practicum activities. Discussions on practical activities do not contribute to the final grades of students. This is quite different from the discussion in e-learning.

In addition to the initiation materials available in the LMS, students are also given a printed module equipped with a CD containing a guide for practicum activities to be carried out. The existence of this CD aims to make it easier for students to carry out practicum activities while at the same time providing an overview of what activities will be carried out, what are the correct procedures in carrying out practical activities and what tools and materials are needed [15]. For now, the use of CDs has not been very effective.

The CD attached to the module tends not to be accessed by students. To open videos contained on CDs, students need additional devices such as CD players or external CDs on a PC. This condition is quite burdensome for students because the CD has not been very effective in helping and facilitating students to gain initial knowledge about

Table 1. Summary of Curriculum Analysis Results for Physics Practicum Course 2

No	Topic	Potential to cause misconceptions (yield in %)		Abstract Material (yield in %)		Hazardous practical material (yield in %)		Need AR media (yield in %)	
		Yes	No	Yes	No	Yes	No	Yes	No
1	Optik geomteri	12,5	87,5	12,5	87,5	0	100	75	25
2	Optik fisis	37,5	62,5	50	50	0	100	87,5	12,5
3	Listrik statis I	62,5	37,5	87,5	12,5	62,5	37,5	87,5	12,5
4	Listrik statis II	75	25	87,5	12,5	75	25	100	0
5	Listrik dinamis I	87,5	12,5	75	25	75	25	87,5	12,5
6	Listrik dinamis II	87,5	12,5	87,5	12,5	62,5	37,5	75	25
7	Elektromagnet I	75	25	87,5	12,5	75	25	75	25
8	Elektromagnet II	87,5	12,5	87,5	12,5	87,5	12,5	87,5	12,5

practicum activities. To analyze student needs for Physics 2 practicum activities, needs analysis activities with student respondents are required and an analysis of the curriculum related to the characteristics of the material contained in the Physics 2 practicum course.

3.2 Curriculum Analysis on Physics Practicum 2

In the Physics 2 practicum course, there are 9 modules, and module 1 contains an introduction to the material so that no practicum activities are carried out. Topics of material in the Physics 2 practicum course include geometric optics, physical optics, static electricity I and II, dynamic electricity I and II, and electromagnets I and II. Curriculum analysis of the material is carried out by examining the content of the practicum material in each module. The material review is carried out by looking at the misconceptions generated by the material, the abstraction of the material, the availability of tools, the safety of practical activities and the need for AR technology in carrying out practical activities. The results of the analysis of the curriculum review and the content of the Physics 2 practicum course material are presented in Table 1.

Based on Table 1, the Physics 2 practicum material has the potential to cause misconceptions in students, especially materials related to electricity and electromagnets. Practical activities on electricity and electromagnets have the potential to cause misconceptions because the concept of material is abstract. To make students' understanding increase and the material is no longer abstract, a media is needed as a solution. When AR media was offered, almost 80% of respondents agreed that AR media was needed to help carry out student practicum activities. AR can visualize abstract material or can also be used to guide the implementation of practical activities [16]. On this basis it

can be concluded that AR media is a necessity in helping students carry out Physics 2 practicum activities.

3.3 Needs Analysis of Basic Physics 2 Practicum by Students

To get responses from potential users, an analysis of the needs of students in the implementation of Physics 2 practicum activities is carried out. The CD serves to provide initial knowledge to students regarding the practicum activities that will be held.

Students' expectations when analyzing answers are that there is a media that is practical, efficient, technology-based and can be used practically on smartphones. AR is a technology that is practical, effective and efficient [17]. The existing media contains practical guidelines which are inserted into the module so as to help students understand the steps and procedures for implementing practical activities. Based on the findings in the analysis of student needs, it can be concluded that AR technology-based media is needed that is practical, effective and can be inserted into the practicum module. The existence of AR media is expected to be a solution because AR media offers a visual experience that can enrich students' understanding of the practicum procedures that will be carried out. AR media is practical to use because to operate the AR media, it is enough to point the camera at the available markers. The availability of marker features helps students to easily operate AR media, showing practicum guide videos without having to use external applications.

3.4 Physics 2 Practicum Module Design Using AR Technology

After conducting curriculum analysis and analysis of student needs, it can be concluded that to launch Physics 2 practicum activities, an AR technology-based media is needed. AR technology is embedded in the print module so that students can study independently before the practicum activities are carried out. Another advantage of AR technology is that it can be operated offline, so it does not depend on network stability. Video integrated using AR serves as guidance, becomes a basic reference in the implementation of practicum activities and provides an overview of practicum activities that will be carried out [18, 19].

In a practicum activity, guides and videos are needed that contain an overview of the implementation of practicum activities, this aims to make practicum activities more focused and guide students to achieve practicum goals well [20, 21]. In the module that is integrated with AR technology, several videos are arranged which are inserted in each practicum guide. Students can download the AR application first, then can operate AR technology on the module by scanning the marker. The appearance of the Physics 2 practicum module that has been inserted by AR technology is as in Fig. 2.

The sequence of practicum steps available in the practicum guide module starts with the theoretical basis, experimental objectives, tools and materials, experimental preparation, experimental procedures, and practicum worksheets. AR material is inserted in the 4th stage, namely in the experimental preparation section as shown in Fig. 2. Students can point their smartphone at the available markers, so that they can bring up video guidance for practicum activities. Students can study this AR technology-based video material before carrying out practical activities and without the need for a stable

D. PERSIAPAN PERCOBAAN

Sebelum anda melakukan percobaan anda dapat menonton video *Augmented Reality* tentang pratikum hambatan dalam dengan menggunakan aplikasi yang sudah anda *download* sebelumnya pada petunjuk penggunaan aplikasi. Berikut langkah-langkah mengakses video pratikum hambatan dalam.

a. Buka aplikasi video *Augmented Reality* pada *handphone* anda.
b. arahkan kamera belakang handphone anda di atas marker pratikum hambatan dalam dibawah ini.

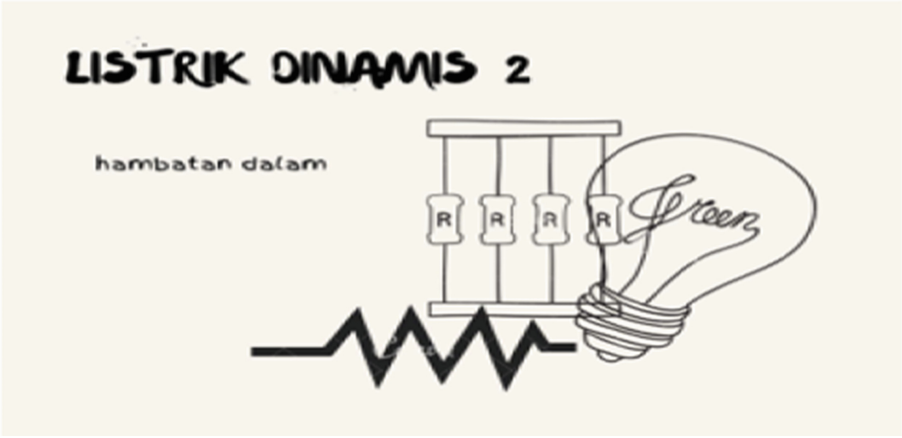

Fig. 2. Display of Markers Inserted into the Physics Practicum Module 2

Fig. 3. The Use of AR Technology in Guiding Students Carrying Out Practicum

network. The AR technology embedded in the module can be accessed offline, provided that the camera quality for scanning is in good condition. AR technology is available for all smartphones and can be downloaded in the installation guide provided on the module (Fig. 3).

Based on the picture, it can be seen that to operate the practicum guide video, a smartphone is needed to scan the marker provided in the module. When the smartphone

is pointed at the marker, a practicum video will automatically appear. In order for the video to be displayed in good quality, users are expected not to move the smartphone out of the marker scanning area. Based on short interviews with students when the module that had been inserted with AR technology was run, the students agreed that this AR media was practical and easy to use. In addition, the AR technology that is inserted into the module really helps students understand the content of practicum activities. Students do not have to bother with playing CDs that are inefficient in their use. Based on the results obtained in this study, it can be concluded that the AR media design which is integrated into the module can be carried out on validity testing by experts. The assessment is carried out on aspects of learning design and content contained in modules that have been inserted with AR technology.

4 Conclusion

Physics 2 practicum activities require AR media as a companion technology to make it easier for students to carry out practical activities. The video guide available in the AR technology-based module helps students get an overview and overview of the practicum activities that will be held. The design of the AR technology-based Physics 2 practicum module designed in this study has been prepared by taking into account the aspects of ease and practicality in use. Initial trials that have been carried out by researchers show that the Physics 2 practicum module based on AR technology is practical to use. In the future, the validity, practicality and effectiveness of the AR technology-based Physics 2 practicum module will be tested so that it can be widely used and distributed to students on a large scale.

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