An Augmented Reality on the Introduction of Escherichia Coli Bacteria that Cause Diarrhea Using the Marker Based Tracker Method

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Abstract Indonesian current educational curriculum demands learning media for the high school degree. The use of learning tools that utilize technology nowadays is more emphasized to get better learning comprehension. Augmented reality (AR) is virtual information to a direct or indirect view of a physical object. This study aims to apply Augmented Reality technology using the Marker Based Tracking method, which is intended as a learning tool for introducing bacteria, especially Escherichia Coli bacteria, to make it easier and fun to understand. This study uses data collection methods that include literature study, interviews, and questionnaires. Approach methods include designing, creating, and testing Augmented Reality. The results of this Augmented app can help both teachers and students in the teaching and learning process as well as inspire the students to learn Biology for Escherichia Coli bacteria material.

Keywords Indonesian education · Learning media · Augmented reality · Marker based tracking · *Escherichia Coli*

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1 Introduction

It is no secret that Augmented Reality (AR) has become a hot research topic. AR integrates 2D and 3D objects from the virtual world into the real world, allowing users to touch, see, and hear them. Due to a real-time training discipline, AR offers excellent opportunities in science and engineering. By using the AR technique, it allows us to get a different and unique exploration and learning experience because it involved us directly [1].

As we know that the learning system in Indonesia still uses conventional learning methods, namely teacher-centered learning with various supporting media such as books and other educational tools [2]. For example, In the field of science learning, teachers rely on pictures in their books to teach [3], especially in recognizing bacteria. This is not fascinating for students during the course [4].

When conducting experiments in the laboratory, there are many obstacles faced by teachers and students, such as the resources in the laboratory are limited, the cost for providing the tools and materials that are needed to build an accurate laboratory model is not cheap, the time that needed to prepare tools and equipment before researching in the lab, some students will ignore the study because it is not attractive. It is dangerous in its implementation [5]. Those are such cases that occur in educational institutions today. These negative things will prevent an experiment from being held, which results in students' lack of experience with experiments in specific fields [6, 7].

One example of an experimental form for students is to study parts of bacteria that are only generally described in student worksheets or schoolbooks. Students cannot conduct experiments directly [8]. Therefore AR is the best solution to this problem, significantly since today's smartphones are overgrowing and can be used as a tool to develop an Augmented Reality [9, 10].

In this study, users are expected to visualize one of the bacteria, namely Escherichia Coli, in 2D and 3D, in real-time. Along with the app as the results of this study later aims to be a media or tool to provide an overview of one form of bacteria, namely Escherichia Coli which is one of the bacteria close to humans that causes diarrheal disease, in 2D and 3D forms with explanations and movements to make teaching and learning process more attractive for both teachers and students.

2 Literature Review

This research highlights the usefulness of Augmented Reality as media learning. It is very necessary to improve the learning process, to vary the way technology is utilized in education. Many things and objects are learned with increasing reality. As in previous studies, the case studies and their respective challenges have tried to do the same.

Even as a learning medium with different models, Augmented Reality technology developed in different areas [11]. The researcher is exploring augmented reality

augmented reality technology is also proposed as part of the project. There were also comparisons of the accuracy and real-time interaction of various feature detection and matching methods [21].

As measured by Bloom's cognitive level, the study examined the effects of Augmented Reality on students' learning outcomes and biological attitudes. It has been redesigned with an AR form. Through quasi-experimental pre-testing and post-testing concepts, the effectiveness of the developed book on learning results and biological attitudes was evaluated. The students also gathered feedback on the augmented reality technology and the redesigned book, and other topics.

Sixty-eight students from the 9th grade participated in this study. Their learning materials included a printing book and augmented reality technology, used as an educational supplement. According to the study's findings, students' learning results and attitudes toward biology improved as a result of AR technology. Students pointed out that AR can help them learn more about biology by incorporating it into their studies [22].

In an experiment, the child's performance in learning was examined, including the number of mistakes they made, their ability to retain the information they had read, and their satisfaction with three different types of teaching materials, including a picture book, physical information, and an AR graphics book [23, 24]. These three teaching materials were created to delineate the characters of six bacteria using 2D graphics, 3D physical items, and 3D virtual objects, respectively. Each time the mobile device scans a commonly found item, a 3D display of bacteria is displayed. As a result of simulating different conditions for the bacteria, users can control their aesthetic behavior in 3D format [25]. A lack of training or differences in color perception can cause non-specialists to misunderstand colorimetric tests. Colorimetric signals are detected and interpreted using a method that allows anyone to understand the results. Nanoparticle-based immunoassays generate colored signals, which are detected by a camera [26].

Learn the names of the six different bacteria. Seventy-two fifth-graders were randomly selected for study and divided into three groups. According to the results, the AR graphics book provides children with a practical and convenient way to explore and learn about bacteria. During follow-up interviews, the children expressed appreciation for the AR graphic book and preferred other types of materials [27].

3 Research Method

At this section, a detailed and comprehensive research flow will be described. Starting from needs analysis, building the apps, until analyze product output from research. As can be seen in Fig. 1, with the explanation as follows:

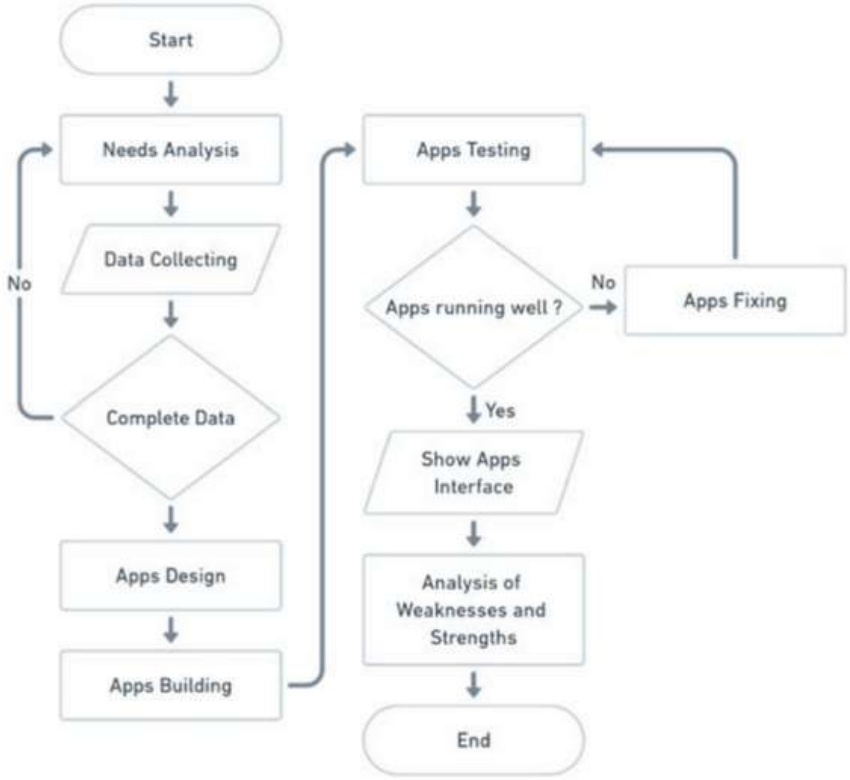

Fig. 1 Research flowchart

(1) The first stage, analyzing the needs of the app that will be designed.
(2) The second stage, data collecting that related with the topic of research, for example, a reference data source is needed regarding the use of AR in education, data related to Escherichia Coli bacteria, and others.
(3) The third stage check the data that has been collected, whether it is complete and in accordance with the need's analysis at the beginning of the study.
(4) The fourth stage, designing the app by cornering one point of the problem topic, the purpose of making the app, the benefits of the app, registering the tools to create the app, an overview of the app through mockups or flowcharts.
(5) The fifth stage, building the app that have been designed.
(6) The sixth stage, the app that has been successfully made will be tested for the effectiveness of the app design, if it is not in accordance with the app design, the concept of the app will be corrected and retested. If it is in accordance with the app design, it will be continued with the stage of giving an aesthetic or beauty impression, namely the appearance of the app.
(7) The seventh stage, conduct an analysis of the app that have been successfully made, find out about the advantages and disadvantages.

3.1 Data Collection

The initial stage in the analysis is data collection, the collection of data used in research. The methods used in collecting data and information are:

Literature Review. At this stage the researcher collects and studies all kinds of information related to the application of Augmented Reality and its programming model [28][29], through papers, journals, books and the internet.

Interview. The researcher also conducted interviews with teachers of SMAN 2 Samarinda regarding the syllabus for learning the structure of Escherichia Coli bacteria, learning methods for students, problems that often occur in learning the structure of bacteria, and others.

Questionnaire. After testing the AR app that has been create, the researcher also distributed questionnaires in the form of several questions regarding the results of the app trial to several respondents [30][31], namely class X students of SMAN 2 Samarinda, general public at all levels of education, and biological students of Faculty of Teacher Training and Education at Mulawarman University. With a list of questions as follows:

1) Does 3D animation interesting and easy to understand?
2) Does the app easy to operate?
3) Does the interface design of the app attractive?
4) Does the information in the information section easy to understand?
5) Does the learning by using leaflets able to increase the interest of app users for studying?
6) Can the app increase interest in learning?
7) Can the learning using marker methods improve user understanding of the app?

3.2 System Design

The researcher develops an Augmented Reality (AR) app based on Android mobile with the aim as a media to learn about the structure of plant roots. The researcher uses the Research and Development (RAD) method to meet quality standards with app development [32][33]. The stages of the development procedure carried out by the researcher as follows:

Requirements Planning. In this section, the researcher identifies the purpose of making the plant structure AR application for the biology teacher at SMAN 2 Samarinda, then identifies the information requirements of the goals discussed and agreed.

RAD Design Workshop. Entering the design and app development stage, the researcher creates and shows a visual design and work pattern for the Escherichia Coli Bacteria structure AR app that has been built for the biology teacher at SMAN 2 Samarinda. The researcher then examines each module which is made based on the teacher's response.

Implementation. After the researcher and biology teachers of SMAN 2 Samarinda agreed on all aspects and work patterns on the AR app of Escherichia Coli Bacteria structure built by the researcher, a trial and introduction of the AR app was carried out to the students of SMAN 2 Samarinda with the aim for being an Escherichia Coli Bacteria learning media.

Augmented Reality Application Flowchart. The system design flowchart shows research and Augmented Reality application stages. It described in Figure 2. It explains the stages as follows:

1) The first stage, the researcher analyzes what object that needed for the app.
2) The second stage is to do a general description of the layout and AR objects manually using paper, scribbles or using a design app on a personal computer.
3) The third stage, modeling the objects and layouts that have been designed and manually drawn earlier in 3D using 3D Blender app.
4) The fourth stage, if it is appropriate then the 3D and 2D designs apply to the app (Unity). At this stage the author applies and installs the design that has been made earlier into 3D form on a predetermined marker.
5) Fifth stage, By pointing the camera at the marker, you can test the app's ability to read it.

6) Sixth stage, If the marker is detected, a 3D object that has been previously designed will appear.

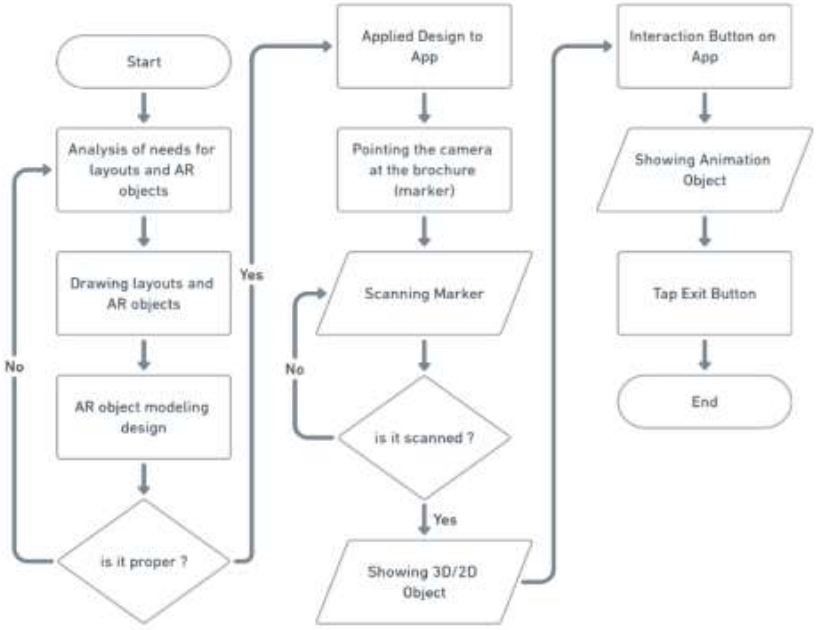

Fig. 2. Augmented Reality Application Flowchart

4 Results and Discussion

4.1 Research Results

User. Users of this Augmented Reality (AR) app are practitioners and participants in teaching and learning activities (teachers and students) or the general public who want to learn biology, especially for Escherichia Coli bacteria [10].

2D Markers. The 2-dimensional (2D) marker used for this AR application represents the interview results, that is, the structural model and micro shape of the Escherichia Coli bacteria. The E.Coli marker brochure was made using a design app, namely Corel Draw X7 [11]. This brochure contains project markers for E.Coli bacteria that have previously been stored in the database at Vuforia.com, and the marker is designed in the form of a brochure, as shown at Figure 3;

Fig. 3. Escherechia Coli Brochure

Local Database. Built-in local database for AR application, in this case using the Vuforia SDK function itself to store and create an AR database [12], here the researcher creates a database entitled Bacteria_EC in Vuforia.com, which has provided this facility.

Fig. 4. Vuforia Database

3D Models. The 3D model used is a micro and macro 3D model of Escherichia Coli bacteria. The following 3D models are also equipped with animations to make it easier for users to understand every shape and function of the Escherichia Coli bacteria body. The 3D model used is E.Coli in macro and microforms.

4.2 Application Interface Testing

Fig. 5. Main Menu

Fig. 6. Hint Menu

Fig. 7. Macro Scan Menu

Fig. 8. Micro Scan Menu

4.3 Device Test

Layout. In developing an Augmented Reality app for Escherichia Coli bacteria, the recommendation of aspect ratio size is 16:10 (Landscape). After finishing building the App, it was tested on several smartphones to check compatibility with the layout of the Android version and a certain screen aspect ratio [34]. The App is installed and running smoothly. Device testing was carried out directly on 36 smartphones belonging to several students at SMAN 2 Samarinda and students of Informatics. Ten smartphones with different Android versions and screen resolutions have been run in a series of tests, resulting in layout compatibility by the system design on the Unity 3D app. The following is a list of 10 smartphones that have been tested based on smartphone brands and different Android versions:

Fig. 8 Micro scan menu

belonging to several students at SMAN 2 Samarinda and students of Informatics. Ten smartphones with different Android versions and screen resolutions have been run in a series of tests, resulting in layout compatibility by the system design on the Unity 3D app. The following is a list of 10 smartphones that have been tested based on smartphone brands and different Android versions (Table 1):

Memory Capacity. After testing the device, it shows that app transfer from the flash disk takes a long time. All of the 33 participants in the trial took a considerable amount of time, affected by the insufficient memory capacity of the participant's device to accommodate the app size of 50 MB.

Minimum Operating System. The participants of the app device test were 33 students, and five students were unable to transfer the soft-file app and could not install the app. Therefore, this app can only be used and runs smoothly on Android devices, at least in Lollipop to Pie versions. Meanwhile, four of the five students mentioned have devices with the IOS operating system, and the rest are Android devices with version 4.

Maximum Camera Distance. The test was aimed at class X MIPA 1 at SMAN 2 Samarinda, including a scan application test. This test resulted in several conclusions, and those are the camera used also affected this test. From the tests that have been carried out, the maximum distance from the brochure media with the camera is 1 m to maximize the marker's reading.

Table 1 App layout test

Device name	Android version	Screen resolution	Layout compatibility	Smoothness
Samsung Galaxy Ace 3	4.0	1280 × 720 (16:9)	Unable to install	Unable to install
Oppo A37	5.1	1280 × 720 (16:9)	Compatible	Smooth
Oppo A39	5.1	1280 × 720 (16:9)	Compatible	Smooth
Galaxy J5	6.0	1280 × 720 (16:9)	Compatible	Smooth
Xiaomi Redmi 4	7.1	1280 × 720 (16:9)	Compatible	Smooth
Redmi 5A	7.1	1280 × 720 (19:9)	Compatible	Smooth
Vivo Y71	8.1	1440 × 720 (18:9)	Compatible	Smooth
Xiaomi Note 3	9.0	1920 × 1080 (16:9)	Compatible	Smooth
Redmi note 7	9.0	2380 × 1080 (19:9)	Compatible	Smooth
Asus Max Zenpro M1	9.0	2160 × 1080 (18:9)	Compatible	Smooth

4.4 Questionnaire Test

Questionnaire testing results from a high category for the feasibility of the question using the SPSS application for the Validity Test with the results of the Pearson Correlation reaching more than 0.7, which means the questionnaire used is valid.

Then, a Reliability Test was also carried out to test the questions used whether they can be reliable with an app made using the same app, namely SPSS. It shows that the results of Cronbach's Alpha on Reliability Statistics, which means it reaches the high-Reliability category.

In addition to the two tests that have been mentioned, the results of the questionnaires that have been distributed are positive and exceptionally qualified to be distributed to SMAN 2 Samarinda so that they can be used as teaching media in the following year's learning. This can be seen from the graph where the percentage of answers strongly agree and agree from the respondents range from 88.2 to 94.1%, with each percentage of Strongly Agree and Agree, which can be seen at Fig. 9.

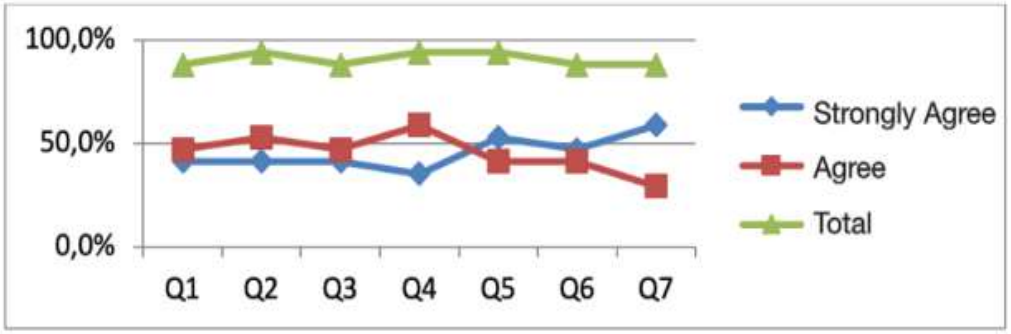

Fig. 8. Respondents Positive Percentage

5 Conclusion

It can be concluded from the results and discussions that the accuracy of markers on Vuforia, soft and hard file brochures, smartphone camera, and lighting when scanning all impact the smoothness of a marker scan. The results of the application test based on the distributed questionnaire showed that each question from the questionnaire obtained results indicating a positive response from application users based on the percentage range of answers "yes," "agree," and "strongly agree," including the Direct Test Questionnaire for high school students ranging from 41 .2% to 100%, Questionnaires for FKIP Biology Mulawarman University Students' which ranged from 58.4% to 91.7%, Questionnaires for the General Public, High Schools to Students which ranged from 76.7% to 97.7%. The results of the device usability testing show that the app has been able to be distributed to high schools because it has met the specified criteria, precisely the number of trial participants who run smoothly until the last stage must exceed half the value of the number of present trial participants.

6 Suggestion

Based on the findings of the assessment for the Escherichia Coli Bacteria AR app, several suggestions for further app development should be implemented not only on the Android platform. The need to further increase the role of education in the mobile app as an enhanced reality as an educational media so that this country has an identity and does not always follow other countries. In this app, the role of education is only an overview of biology material, especially bacteria. Furthermore, it can be improved by increasing the role of education in other fields of study, such as chemistry learning media, and so on.

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