The development 3-D augmented reality animation on radioactive concept

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Abstract. Augmented Reality is a technology that can provide positive perceptions of lessons, improve learning experiences, and improve learning achievement. It visualizes the phenomenon obtained by the results of laboratory research. This research was to design and develop the marker of radioactive concepts. The stages consist of determine the instructional needs and goals, develop the markers, and quality review. We generate two markers for this concept: radioactive light penetration and radioactive light beam by electric field. The markers were developed based upon the identification of instructional needs and expected to assist in the achievement of the instructional objectives. The results of the development show that AR animation markers on the radioactive concept can be read and have maximum readability of 25 cm.

1. Introduction
The use of Augmented Reality (AR) technology in learning includes exploration, simulation, and games [1]. This categorization based on the purpose of learning objectives. In science learning in class, AR more used in the form of simulation. Interactive simulation in delivering physics concepts [2]. Interactive simulation is a trend in the development of learning media for learning Physics, various interactive simulations obtained from PhET [3].

AR technology can be applied to improve learning activities in the laboratory [4]. AR technology is proven to be able to increase/vary experimental activities and provide new experiences in studying microscopic physics concepts such as thermodynamics [4]. AR technology also can be used to display simulations of electrical physics concepts [5]. In the AR learning syntax, it functions as a scaffolding that can help better understanding [6]. AR visibility in designing learning activities that are dynamic in nature because they are able to present the academic environment through simulation with a wide range [7]. AR is very promising in increasing student motivation and can increase greater student involvement in the learning process [8].

The challenge of implementing AR Technology in classroom learning is usually related to the level of access to hardware or software needed to access AR [9], although now the problem is almost non-existent. The current learning trend is always following technological improvements, so it is not hard to find students using mobile devices in class.

The technological used to use Virtual Reality (VR) has similarities with AR, so it is possible to implement it in class [9]. VR-based 3D simulations show excellent learning experience and create a pleasant atmosphere [10]. Also, the use of AR or VR can facilitate high-level thinking skills and provide cognitive scaffolding where students can build their conceptual understanding of concepts and
intellectual skills through interaction with virtual objects [11]. AR and VR technology can deliver messages with higher interactive capabilities than other media, even delivering messages by providing different experiences, for example, on the concept of radioactive waste [12]. Development of radioactive concept teaching media can be done by the through experimental activities through an exploration of natural radioactivity with good visuals [13]. So, our research is about understanding radioactivity. This preliminary study focuses to generate two markers for this concept: radioactive light penetration and radioactive light beam by the electric field with AR technology.

2. Materials and method
The materials are two markers and must uploaded on Vuforia. The materials of 3D animation was developed by using Blender. The stages consist of determine the instructional needs and goals, develop the markers, and quality review.

2.1. Instructional needs and goals
In this research we prepare indicator for radioactive concept lesson in high school. The indicators are students able to:

- Identify the influence of the electric field on alpha rays.
- Identify the influence of the electric field on beta rays.
- Identify the influence of the electric field on gamma rays.
- Identify the influence of magnets on alpha rays.
- Identify the influence of magnets on beta rays.
- Identify the influence of magnets on gamma rays.
- Identify the ability of alpha rays to penetrate the paper.
- Identify the ability of beta rays to penetrate aluminum.
- Identify the ability of beta rays to penetrate lead.

2.2. Develop the markers
Created the radioactive light penetration and radioactive light beam by the electric field animations using a Blender. Combined the animations with the marker for showing an AR by using unity 3D software.

2.3. Quality review
Tested the radioactive light penetration and radioactive light beam by the electric field animations using phone and checked the quality review. At this stage, comparison of the readings between the marker and the phone is also carried out as well as the time for AR to appear.

3. Results
We generate two markers and two augmented reality object. Figure 1 and 2 for visualize the radioactive light beam. Figure 1 shows the marker design to scan by AR camera. Figure 2 shows the 3D object that appear from AR application.
On the radioactive light beam concept by using this AR animation, students are able to identify the influence of magnets on: (1) alpha rays, (2) beta rays, and (3) gamma rays.

On this radioactive light penetration animations, students can identify: (1) the ability of alpha rays to penetrate the paper, (2) the ability of beta rays to penetrate aluminum, and (3) the ability of beta rays to penetrate lead.

Another visualization of bending radioactive rays by an electric field is shown in figure 5 and 6. Students are able to identify the influence of the electric field on: alpha rays, beta rays, gamma rays.

Based on the results of testing the time needed to display the 3 Dimensions (shown in Table 1), it found that the higher the distance between the marker and the mobile phone, the size of the three dimensions shown will be smaller and over time will disappear. This result is the following reference [14]. The maximum distance read on the reference is 20 cm while the research is 25 cm. At a distance of 30 cm, the reference results do not include readability because at 25 cm distance the 3d animation does not
appear, while in the study, the distance of 25 cm is still legible. The difference in results is due to the level of readability of the marker and the focus of the AR camera. The more focused the AR camera used, the faster the 3d animation appears.

| Distance (cm) | Reference [14] | Research |
|--------------|----------------|----------|
| 5            | 0.49           | 0.32     |
| 10           | 0.50           | 0.42     |
| 15           | 1.10           | 0.56     |
| 20           | 1.20           | 1.25     |
| 25           | -              | 1.40     |
| 30           | -              | -        |

In addition to AR animation to understanding radioactive can be done by the experiment. For example, a radioactive concept experimental model is using a remote so students can do experiments online remotely [15]. That study can be used as an evaluation material to develop online AR from the results of development.

4. Summary

The results of the development show that AR animation markers on the radioactive concept can be read and have maximum readability of 25 cm.

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