The Application of Mobile Augmented Reality to Improve Learning Outcomes in Senior High Schools

Nurhayati, Rusdi, and Hanum Isfaeni

Abstract—**Innovation based on technology is important for the learning process, especially in the environmental subject. This research was conducted to improve the learning outcomes of senior high school students using Augmented Reality (AR) for environmental pollution. Our study uses the research and development method with the model from Borg and Gall. The students as objects of research were divided into two classes including the control and experimental groups. The AR learning media was validated by experts in relevant fields with the focus on the three aspects of media, material, and language before it was applied to the students. The validation result for the media aspect was found to be 3.25%, the material was 3.00%, and language was 3.29%, and this indicates the media is valid. The results showed that the average score for the learning outcomes of the control class was 52.6 while the value for the experimental class was 69.8. This signifies the AR learning media developed for environmental pollution contributed positively to the process of learning biology and also fosters student interest in learning. Therefore, the learning media was confirmed to be appropriate for students studying biology subjects.**

Index Terms—**Biology lesson, education media, environmental pollution, teaching media.**

I. INTRODUCTION

There is a very development of technology in the 21st century, thereby, providing quick and easy access to different kinds of information. This presents a great challenge for teachers to create innovative and effective learning media [1] which are ideally needed in this century [2]. It is important to note that learning media is very important and required in the learning process [3].

This is associated with its ability to increase students' understanding of the material and ensure the message being conveyed by the teacher is clearer. It is, however, important to note that most teachers use conventional media which involves using textbooks to teach environmental pollution materials due to limited costs and tools. This normally makes it difficult for the students to understand the materials, thereby, resulting in low learning outcomes that are below the minimum standard. This indicates there is a need for effective learning media such as augmented reality to attract the attention of the students.

Augmented Reality (AR) media will change conventional learning to technology-based learning [4]. It is a medium that combines the real and virtual worlds in real-time [5] hence the learning process is made to look real [6]. AR can be visualized using a camera device or smartphone [7] and its application in environmental pollution materials is expected to visualize the information in 3D images to assist the students in understanding the concept.

AR media can attract students' attention in the learning process [8]. It has the advantage of increasing learning efficiency [3] and outcomes [9] because students are allowed to interact directly with the media to ensure that learning is more effective and meaningful. This means this AR media method can be applied as a solution by teachers in teaching environmental pollution material because of its ability to save costs.

[8] Applied AR media to biology students and discovered that it was more effective, enhance their interest in studying the subject, and also improved learning outcomes. [10] Also showed an increase in mastery of certain concepts after the application of AR media and this increased the students' learning outcomes and facilitated their creative thinking skills. These previous studies showed that augmented reality media has the potential to improve student learning outcomes in biology lessons specifically for the subject of environmental pollution.

II. METHODOLOGY

The method used in this research is Research and Development. The model used by Borg and Gall in this study was carried out until the 9th stage because the purpose of this research was to carry out product development and large class trials. The final product refinement stage is believed to have improved student learning outcomes without distributing the product. I modified the model Borg and Gall according to the needs and objectives of the research [11]. These stages include 1) research and data collection, 2) planning, 3) product draft development, 4) initial field trials, 5) major product revisions, 6) field trials, 7) revisions product of field test results, 8) field implementation test, 9) final product refinement. The AR is proven in previous research. The research was carried out not to the dissemination stage and has potential in student intelligence [7]. In line with further research, they use steps up to stage 7 and achieve the goal [12].

A. Included Studies

The research location for AR media development on environmental pollution material is SMA Negeri 1 Bunguran Utara Natuna. The research subject is class X IPA. Divided into two control classes and experimental classes. The number of subjects in the control class is 23 students and the

experimental class is 20 students. Learning is carried out using textbooks in the control class, while the experimental class uses AR learning media through smartphones. The procedure begins with analyzing student needs and analyzing curriculum, compiling and making research instruments, compiling storyboards and making AR learning media, and then validation by experts. After that, a small group trial was carried out and then continued with the implementation stage of data collection. The research instrument consisted of multiple-choice questions to assess student learning outcomes. This study's multiple-choice questions are in the form of pretest and posttest.

B. Statistical Analysis

Statistical analysis aims to improve student learning outcomes using AR learning media. Analysis of the data in this study is the normality test using Kolmogorov Smirnov assisted by the SPSS v.23 programs. followed by a homogeneity test to determine whether or not the same population is homogeneous. Furthermore, hypothesis testing is carried out through correlation test and t test.

III. RESULT AND DISCUSSION

A. Results

Information gathering begins with conducting interviews with biology teachers and observing students at SMA Negeri 1 Bunguran Utara regarding the use of learning media. The results of the needs analysis obtained from interviews and observations are as follows: 1) lack of use of learning media following the characteristics of the material, so that the use of learning media needs to be increased, 2) students have difficulty learning and understanding abstract material so that learning outcomes are below the minimum standard.

B. Development of Augmented Reality (AR) Learning Media

The process of developing AR learning media using the Vuforia software application. Beginning with making a storyboard, then continuing with creating AR objects and then markers that function as markers for AR learning media during the scanning process. Learning media is presented in Indonesian and is equipped with a companion module for AR learning media for students. The following is a display of AR learning media (Fig. 1).
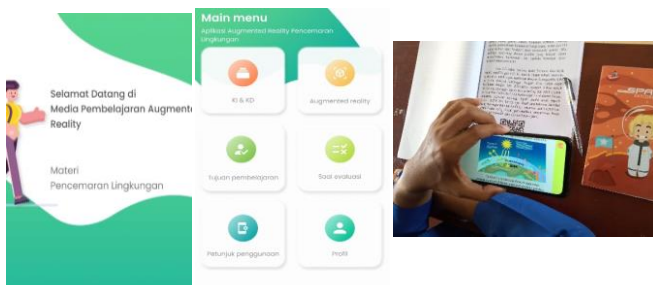

Fig. 1. Augmented reality learning media display.

Experts then validate the finished learning media to see the feasibility of the media before being used by students. It consists of 3 experts conducting the assessment, namely media validation, material validation, and language

validation. The following are the results of validation from experts (Fig. 2).
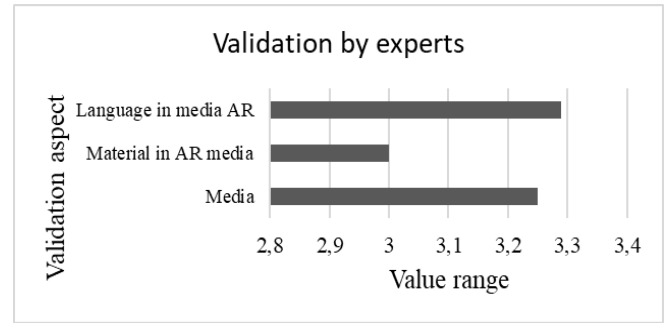

Fig. 2. AR learning media validation by experts.

The validation results that have been carried out can be seen in Table I. The first assessment is to assess the feasibility of AR media. The aspects assessed on the media aspect are learning communication, visual communication, use, and AR applications. The percentage obtained from the media validation results is 3.25 valid. The second assessment is to see the feasibility of the material contained in AR media. The aspects that were assessed were the feasibility of the content and the design of the lesson. The percentage obtained is 3.00 valid. The final assessment is language validation on AR media. The aspects assessed are straightforward, linguistic, written grammar, and suitability for students. The percentage obtained is 3.29 valid. Based on the validation results obtained from 3 validations by experts, the AR learning media was declared valid to be used by students. If a product has been tested for feasibility, the product developed is valid for use by students [13].

C. Improving Student Learning Outcomes

The learning outcomes data obtained by the students were then analyzed using the SPSS V.23 program to see the findings of the research. The test was carried out with a series of statistical tests in the form of normality, homogeneity, and t-test to determine the difference between the two groups. Then the data are presented in the descriptive form of pretest and post test scores between the control class and the experimental class.

TABLE I: STATISTICAL TEST RESULTS FROM LEARNING OUTCOMES USING AR MEDIA

Data type		Pretest		Posttest	
Normality test	sig.	0.200	0,180	0.80	0.200
	int.	Normal	Normal	Normal	Normal
Homogeneity Test	sig.	0.910		0,88	
	int.	Homogen		Homogen	
Independent Sample t-test	sig.	0.910		0.345	
	int.	Significant		Significant	

Table I presents a statistical analysis of student learning outcomes data. The statistical analysis begins with a normality test to see if the data are presented normally distributed [14]. Based on the normality test for the pretest data in the control class, the dig value is 0.180 or more than 0.05. While the value in experimental class for pretest is 0.200> 0.05, which means the data are normal, and the data was analyzed with other statistical analyze. Furthermore, the data were analyzed with a homogeneity test to know several

population variants were the same or not [15]. The homogeneity test is important for an independent sample t-test [16]. The result shows that pretest data got a sig value of 0.910 or > 0.05, meaning that the data are homogeneous. Likewise, the post-test data got a sig value is 0.88 > 0.05, which means the data are homogeneous. The homogeneity test showed if the population are homogeneous.

The Independent sample t-test was followed to measure the difference for an average between the pretest and post-test. After the T-test that the pretest score of Sig. 0.910 <0.05, while the post-test of 0.345 <0.05. We could conclude a significant difference in the t-test on student learning outcomes.

Fig. 3 is the average result value of student learning outcomes presented in the table.
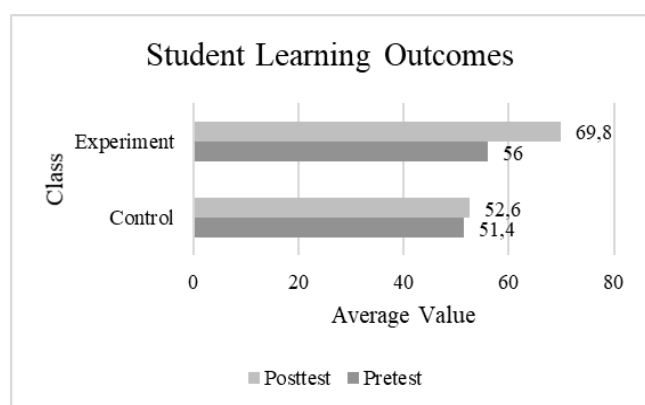

Fig. 3. Improved inter-class learning outcomes.

Based on learning outcomes obtained between the control and experimental classes. The average value of the pretest in the control class was 51.4, and the post-test was 52.6. While the pretest value in the experimental class was 56.0, and the post-test was 69.8. There was an increase in learning outcomes after students used AR media. The experimental class post-test learning outcomes significantly impact the development of students' knowledge. After doing it, it gives its satisfaction to students in increasing learning. Students' learning difficulties can be overcome by using AR learning media.

D. Discussion

Observation data showed that students had problems in the enviromental learning process because of the lack of appropriate learning media. This problem impacted student learning difficulties by 92 % and influenced students' cognitive outcomes. AR learning media is needed to solve these problems. In line with subsequent research that the use of AR learning media has a positive impact on sharpening students' thinking power so that they can improve learning outcomes [17].

Developing AR learning media based on Borg and Gall model was created to describe how environmental pollution happens. AR can generally give a deep impression on students because it involves several senses [18]. In addition, there are actual animations that can move so that learning is more interactive. The completeness of learning media is essential in improving the quality of knowledge [19]. The material used as AR learning media is explained in detail and interestingly and is equipped with a companion book.

Learning media becomes good when presented in an exciting, not monotonous way [20]. In operational field tests conducted directly by senior high school students, AR media learning made students more active and subjects easy to understand, increasing students' learning outcomes.

There is a significant difference between the pre-test and post-test students in the control and experimental classes. The main focus of this research is to develop AR learning media products to improve student learning outcomes. The AR media provide students with learning experiences about environmental pollution material [21]. Students' learning experience is obtained from the material presented in a language easily understood. With material that is easy to understand, it makes students interested in participating in learning [22]. The clarity of the material is explained one by one in detail so that students easily accept it.

Students are divided into two classes which are treated differently. The control class learns conventionally using textbooks, while the experimental class uses AR learning media. The results showed that AR learning media in the experimental class had a positive impact compared to the conventional learning control class. The combination of using images and moving animations in AR makes learning a fun atmosphere. AR learning media uses a combination of colors in contrasting writing to appeal to and improve learning memory. Learning by using AR programs has a positive impact on students, one of which is learning to be fun and improve students' memory [23]. With the help of AR, it will provide a student learning experience when presented using contrasting and exciting objects and writing [24].

If compared to the control class, the experimental class's pretest and post-test scores have much influence on learning by listening to the teacher's lectures assisted by textbooks. The teacher writes some material on the blackboard and the concept of environmental pollution material. In this way of learning, students tend to be bored and do not pay attention to the ongoing learning. The conventional method of learning makes it difficult for students to understand abstract concepts and causes students to lose concentration in class [25]. The display of AR objects is presented in a 2-dimensional form that resembles actual events. Moving AR objects help students understand the processes that occur, for example, in the case of acid rain. AR applications are student-centered to explore lessons actively [26]. AR applications help students provide more knowledge by visualizing difficult material to imagine [27] and assisting those with low visualization levels [28]; with AR, students will quickly see the object clearly [29].

In addition, AR learning media provides learning motivation for students. As stated [30], the involvement of AR media provides students' learning motivation. Learning using AR media allows students to be active during learning and provide learning encouragement [31]. Based on this, AR learning media has an essential role in improving student learning outcomes compared to conventional learning [32]. The convenience possessed will be helpful for future learning [24]. Such as more interactive and collaborative learning that occurs [33].

IV. CONCLUSION

This research showed that ar learning media could improve learning outcomes. The AR learning media was proven by the experimental class's increase in post-test learning outcomes. In addition, AR provides more learning support for students in understanding environmental pollution material, creating an interactive learning atmosphere, and encouraging student learning motivation. Moreover, learning media, AR, provides a variety of learning methods for teachers.

CONFLICT OF INTEREST

During the research, we state that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

In this study, the first author became the principal researcher. As a research proposal collecting field data, the second author understands ideas and performs data calculations. The third author plays a role in determining the title of the study. All authors discuss the results and contribute to the final manuscript.

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