Augmented Reality Based on Discovery Learning: The Human Circulatory System to Improve Biological Literacy

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Abstract: To produce Augmented reality learning media products based on Discovery learning on circulatory system material, assessing the feasibility and effectiveness of Discovery learning based Augmented reality learning media products on circulatory system material in the learning process of class XI students at SMA Plus Sedayu Nusantara. This research is a Research and Development (R & D) development research with the ADDIE development model. Subjects included 2 material experts, 2 media experts, 3 students in the individual test, 9 students in the small group test, and 30 students in the limited field test. The results showed that: Augmented Reality learning media based on Discovery Learning on the circulatory system is very suitable to be used as a learning resource in learning material for the Circulatory System Class XI SMA; Discovery Learning-based Augmented Reality learning media on the circulatory system is very effective in use, testing the effectiveness of Discovery Learning-based Augmented Reality learning media products on the circulatory system fulfills the criteria of being effectively used which is shown from the results of product effectiveness testing using the t-test on different independent test tests. The average result of the assessment in the experimental class was that the average score of the learning outcomes test was higher than the average result of the control class students who did not use learning media.

Keywords: augmented reality; discovery learning; human circulatory system; biological literacy

1. INTRODUCTION

IPA is knowledge related to how to find out about nature systematically so IPA is not only mastering a collection of knowledge in the form of facts, concepts, or principles but also a process of discovery because IPA is a collection of systematic theories. , its application is generally limited to natural phenomena, born and developed through scientific methods such as observation and experimentation, and requires a scientific attitude such as curiosity, openness, honesty, and so on. According to Susanto [1] argues that science or science is a human effort to understand the universe through observations that are right on target, using procedures, and explaining by reasoning to get a conclusion. Science is part of the subjects that are developed based on the achievement of three aspects, namely knowledge, attitudes, and skills. Biology as part of natural science is a study related to how to find out about nature systematically so that biology is not only the mastery of a collection of knowledge in the form of facts, concepts, and principles but also a process of discovery [2].

Augmented reality is a technology that combines virtual or virtual world objects with the real world. This technology is generally developed on desktop PCs along with technological advances, many applications adopt this technology into a smartphone applications. The application of this technology can facilitate learning by displaying objects. 3D and animation that students are expected to better understand the material [3]. Advances in multimedia technology, especially learning multimedia, can help increase interest in learning because everything is completely digital, one of which is by utilizing mobile devices. The combination of the world of technology and education can provide benefits to the learning process because it has great potential for teaching development, such as through Augmented reality technology. The use of Augmented reality technology in learning has advantages, one of which is that it can train the creativity and imagination of students [4].

From the results of Qumilaila's research [5] Augmented reality technology as a medium of learning has several advantages. AR allows digital content (audio, video, 2D and 3D objects) to appear to merge with the real world through a device. Augmented reality also enables content learning in three dimensions (3D), so that it can visualize things that are hard to see. In addition, AR's ability to present virtual objects to the real world in real time can activate students' sense of presence, immediacy, and immersion.

1.1 Learning Outcomes of Biology

Biology is one of the sciences that is part of the Natural Sciences (IPA) group. IPA is a science that studies natural phenomena, both material and abstract. The results of this natural science can come from experiments, direct observations, or with other scientific methods [6]. Whereas biology material that is integrated with science, many of which are not supported by a complete laboratory, cannot be practiced directly and media is needed to visualize it. Such material is for example the circulatory system, digestive system, heart work, excretory system, cell structure in both plants and animals, the solar system, the movement of animals on the seabed, and so on.

According to Qumilaila [7], biological material can be seen as something simple, but it can also be seen as something complicated and complex. Based on the results of Haka's research and discussion [8], interactive multimedia integrated with scientific values are very suitable for use as a biology learning medium.

Many materials in biology subjects cannot be visualized directly, so they need certain media. Visualization through learning media is one way that can be done to make it look real. Biology materials will be more interesting and easy to learn by packaging them in a digital format. For example, material about cells, and cell images presented in the form of ordinary/two-dimensional (2D) images will certainly be different from cells presented in the form of three-dimensional (3D) animation.

Jayawardana [9] said that teachers need to design classroom learning activities that combine the use of various kinds of technology. With a large number of digital tools and various kinds of information in them, education is needed to guide and foster all of these digital learning processes (e-learning). Digital The teaching and learning process is often faced with abstract material beyond the daily experiences of students so that the material becomes difficult for teachers to teach and difficult for students to understand.

1.2 The Nature of Augmented Reality
Arnaldi [10], Augmented Related is a technology that has sparked many fantastic and interesting things but delivered little. Many have made a virtual reality into the real world and created sensational videos that make the audience believe that what is experienced feels real, then visualize the sofa that will be purchased next as if it is presented in the living room, even

as if it is presenting someone who has died. In short, real life would be exactly like a television series.

Augmented Reality technology is a technology that can combine real and virtual situations displayed in real-time [11]. Augmented reality is the result of technology that can combine the virtual world and the real world that can be used by a teacher because he can project something abstract so that it can be interactive [12]. This technology can combine the real world and the virtual world that raises or projects in all directions according to what we want. The application of this technology aims to enable students to conduct experiments thereby increasing learning motivation. Its use can communicate objects in the virtual world to be used as a positive display so that it looks quite good, it will feel like you are in a much more concrete experience because of the limitations of the five human senses which cannot see directly abstract natural phenomena.

According to Qumilaila [13], Augmented Reality technology as a medium of learning has several advantages. AR allows digital content (audio, video, 2D and 3D objects) to appear to merge with the real world through a device. Augmented Reality also enables content learning in three dimensions (3D) so that it can visualize things that are hard to see. In addition, the ability of Augmented Reality to present virtual objects to the real world in real time can activate a sense of presence, closeness, and immersion in students.

Augmented reality, is a technology that can incorporate a 3D object into a real environment using webcam media. This technology has now been widely developed in developed countries for various purposes including educational purposes [14].
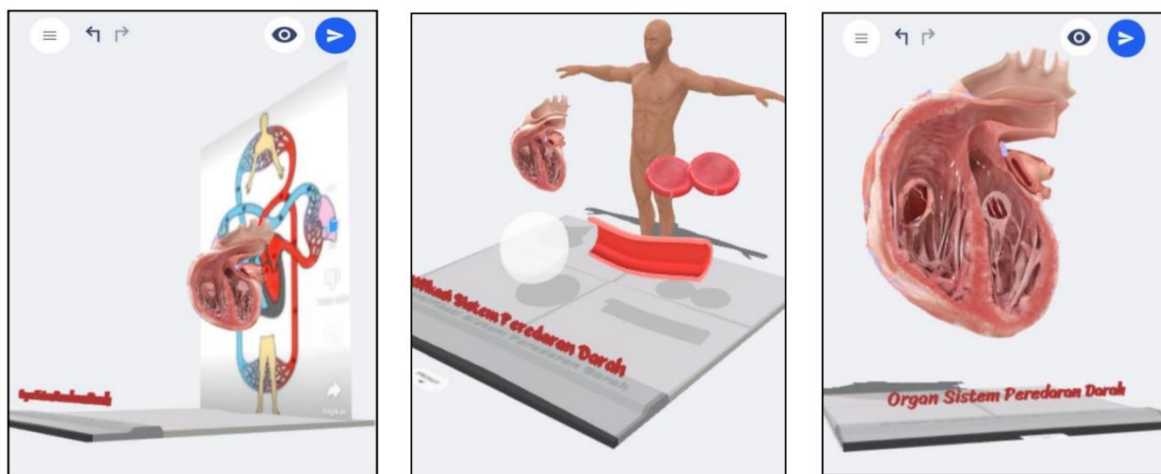

Figure 1. Augmented Reality organs of the human circulatory system

1.3 Discovery Learning Models
Discovery learning is learning based on discovery (inquiry-based), constructivism, and the theory of how to learn. According to the view of constructivism, learning is an active process of students constructing meaning, discourse, dialogue, and physical experience in which the assimilation process occurs and connects the experience or information that has been learned [15]. The discovery learning model is also known as an inquiry approach starting from a belief in the

development of students independently. This model requires active participation in scientific investigations.

The discovery learning model is a learning theory that is defined as a learning process that occurs when students are not presented with lessons in their final form but are expected to organize themselves. In Bruner's opinion [16], "Discovery learning can be defined as the learning that takes place when the student is not presented with the subject matter in the final form, but Raher is required to organize it himself", where

Bruno's basic idea is the opinion from Piaget which states that children must play an active role in learning in the classroom.

According to Khasinah [17], the Discovery learning method is an active and direct learning style developed by Jerome Bruner in the 1960s. Bruner emphasized that learning must be done while doing or learning by doing. With this method, students actively participate and not just passively receive

knowledge. Discovery learning denotes a general instructional approach that represents the development of constructivist learning for school-based learning environments. The procedures for applying the Discovery learning model, namely: (1) Stimulation; (2) Problem Statements; (3) Data Collections; (4) Data Processing; (5) verification; and (6) Generalizations.

Table 1. Discovery Learning model steps in Biology learning

No	Syntax	Activities on Circulatory System Material and Digestive System
1	stimulation Providing stimulation	a) Given a problem that has no solution, for example viewing and observing 3D images of diseases related to the circulatory system motivates them to investigate and solve the problem. b) Students see and observe 3D images, namely pictures of food and digestive organs c) The teacher facilitates them by giving questions, and directions for reading books or texts.
2	Problem Statements Problem Identification	a) Students are given the opportunity to identify as many problems as possible related to the circulatory and digestive systems and their mechanisms, then formulated in the form of hypotheses or temporary answers to the problems set.
3	Data Collections Data Collection	a) Students explore to collect relevant data or information by reading, literature, and observing objects, such as the structure of the heart organ, blood vessels, and small and large blood circulation mechanisms through 3D Augmented Reality objects b) Students try to answer questions or prove the truth of the hypothesis. c) Students seek information about food substances and their functions, digestive organs, and their working mechanisms through 3D Augmented Reality objects.
4	Data Processing Data Processing	a) Students process the data or information they obtained in the previous stage and then analyzed, and interpreted it. All information, both from readings, interviews, and observations, is processed, classified, and tabulated by discussing with the group to get solutions to problems, for example formulating the mechanism of the circulatory and related systems and the digestive system of food and compiling a healthy menu.
5	Verification	a) Students carry out careful verification to test the hypothesis set by alternative findings, linked to the results of data processing. b) Think critically to solve problems by discussing ways to look for ways to prevent disease in the human circulatory system and digestive system and answer the questions.
6	Generalizations Draw conclusions	a) Draw conclusions that can be used as general principles and apply to all the same incidents or problems, taking into account the verification results. b) Presenting the results of group discussions around the circulatory organs, large and small circulatory systems, and efforts to prevent circulatory system diseases. c) Presenting the results of group discussions regarding the digestive organs, food substances, their functions, and healthy menus.

Hosnan [18] and Haerullah and Hasan [19], stated the advantages of the discovery learning model, namely as follows: (1) Helping students to improve and enhance cognitive skills and processes; (2) The knowledge obtained through this model is very personal and powerful because it strengthens understanding, memory, and transfer; (3) Can improve students' ability to solve problems; (4) Helping students strengthen their self-concept, because they gain trust in working with others; (5) Encouraging student involvement; (6) Encourage students to think intuitively and formulate their hypotheses; (7) Train students to learn independently; and (8) Students are active in teaching and learning activities because they think and use their abilities to find the final result.

Based on the problems, the research problems are formulated as follows: (1) How is the development of Augmented reality learning media products based on Discovery learning on the circulatory system material; (2) How is the feasibility of Augmented reality learning media products based on Discovery learning on circulatory system material; (3) How is the effectiveness of Discovery learning-based Augmented reality learning media products on the circulatory system material.

2. METHOD

This research is Research and Development (R & D) development research. Research methods are used to produce certain products, and test their effectiveness of these products. According to Sugiono [20], to be able to produce certain products, research that needs analysis is used, and to test the effectiveness of these products so that they can function widely in society. The model used in development research is the ADDIE development model, namely Analysis, Design, Development or Production, Implementation or Delivery, and Evaluations.

Figure 1. ADDIE Model Process Flow [21]

Research and development (research and development) is a series of processes or steps to develop a new media or improve existing media so that it can be accounted for [22].

The research location is Sedayu Nusantara Plus High School, which is located at Jl Marelan Pasar III Timur, Rengas Pulau, Medan City, where this school is a cadet school. When the research was conducted in odd semesters.

The research subjects were students of class XI SMA Plus Sedayu Nusantara where the study population consisted of all students of class XI SMA Plus Sedayu Nusantara which consisted of 7 classes, namely class XI Mia 1 to class XI Mia 7 class with a total of 205 students. Students as respondents consisted of two classes, namely the control class and the experimental class. The control class (XI Mia 1) had 30 respondents, while the experimental class (XI Mia 2) had 30 respondents. The object of this research is Augmented Reality learning media based on Discovery Learning on the human circulatory system.

Table 2. Expert Validation Questionnaire Assessment Qualification Criteria, and Student Response Instruments to Discovery Learning-based Augmented Reality Learning Media

percentage of Achievement Level	Eligibility	Description
81,26% ≤ X < 100%	Very good/Valid	No need for revision
62,6% ≤ X < 81,25%	Good/Valid	No Revision Required
43,76% ≤ X < 62,25%	Invalid	Revision
25% ≤ X < 39 %	very Invalid	Revision

Source : (Akbar, [23])

Based on the quantitative data from the results of the validator by material experts, media experts, and student response questionnaires, the next step is to analyze the data and calculate the percentage level of achievement based on the formula:

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

Keterangan:
x: The answer score from the validator
x_i: Score the highest answer
P: Presentation of eligibility level

The feasibility and effectiveness criteria achieved for use in media development are described in the following table.

Table 3. Media Eligibility Criteria

No	Score in Percentage (%)	Eligibility Category
1	80 ≤ P < 100	Very Eligible
2	60 ≤ P < 80	Eligible
3	40 ≤ P < 60	Adequate
4	21 ≤ P < 40	Inadequate
5	P < 21	Very Inadequate

The developed Augmented Reality learning media gets a positive response from students if the percentage obtained from the student response questionnaire reaches a score of ≥60%, then the learning media is categorized as feasible and effective.

Product Effectiveness Test Data Analysis Techniques
The effectiveness test aims to obtain information about whether or not the product development being tested is effective in the learning process.

Based on the formulation of the first problem, namely whether the Discovery Learning-based Augmented Reality Learning Media developed is feasible to use. Discovery Learning-based Augmented Reality Learning Media can be said to be feasible to use based on the results obtained from expert validation regarding suggestions and improvements related to the Discovery Learning-based Augmented Reality Learning Media that was developed. The next step is to carry out individual trials of 3 students, and small group tests of 9 students to find out the response to the Discovery Learning-based Augmented Reality Learning Media that was developed. Then a field trial was carried out with 26 students to find out the responses to the Augmented Reality Learning Media based on Discovery Learning that was made.

Based on the formulation of the next problem, namely whether the Discovery Learning-based Augmented Reality Learning Media developed is effective for improving Biology learning outcomes. Learning is said to be effective if there are significant differences in learning outcomes between classes that are given treatment and classes that are not given treatment. The hypothesis uses the mean difference test or t-test. The t-test is the average difference to find out whether there is a significant difference at the 0.05 significance level with Microsoft Excel 19.

The hypothesis formulated is:
Ho: μ1 = μ2 (there is no average difference between the treated and untreated classes).
Ha: μ1 ≠ μ2 (there is an average difference between the treated and untreated classes).
Decision-making Ho is accepted if the significance is greater than 0.05. The following is the calculation using the 2 difference test on the population average according to Sudjana (2009):

$$t = \frac{\bar{X}1 - \bar{X}2}{s\sqrt{\frac{1}{n1} - \frac{1}{n2}}}$$

Where:
$\bar{X}1$ = total average score of the experimental class sample.
$\bar{X}2$ = total average score of the control class sample.
s = standard deviation

3. RESULTS AND DISCUSSION
3.1 Results
The results of the assessment by media experts, material experts, individual trials, small group trials, and limited field trials for all aspects of the assessment are determined by the average score. The results of the assessment are then analyzed and determined whether or not it is appropriate to develop Discovery Learning-based Augmented Reality Learning Media on the material of the human circulatory system. The average percentage of the results of the assessment of media experts, material experts, individual trials, small group trials, and field trials is as follows:

Table 4. Average Percentage of Assessment Results on Discovery Learning-based Augmented Reality Learning Media on Human Circulatory System Material

No	Categorization	Percentage of average score %	Criteria
1.	Media Expert Validation	89,21	very feasible
2.	Material Expert Validation	95,83	very feasible
3.	Individual Trial	86,74	very feasible
4.	Small Group Trial	88,62	very feasible
5.	Field Test	88,03	very feasible
	Total Average	89,69	very feasible

Augmented Reality Learning Media based on Discovery Learning on the material of the human circulatory system from the validation of experts along with trials showed a percentage of 95.83% in media validation, 89.21% in material validation, 95.83% in individual trials, 86.74% small group trials, 88.03% in field trials. Overall, the average percentage is included in the "Very Eligible" category, which means that the use of Augmented Reality Learning Media based on Discovery Learning on the human circulatory system material meets the needs of students.

The data that has been obtained and processed, results that the highest score for the experimental class is 94 and the lowest score is 44. The mean value is 70.90, the median (Me) value is 72.22 and the mode value (Mo) is 83 and the standard deviation value is 14.56. For more details, see the following data.

Table 5. Learning Outcomes Using Discovery Learning-based Augmented Reality Learning Media on the material of the human circulatory system

Class	Interval Class	F. Absolut	F. Relatif %
1	44 – 52	5	16,67
2	53 – 61	6	20,00
3	62 – 70	2	6,67
4	71 – 79	6	20,00
5	80 – 88	8	26,67
6	89 - 97	3	10,00
	TOTAL	30	100

From the data obtained, is then calculated and the result is that the highest value in the control class is 78 and the lowest value is 17. The average value is 55.37, the median value (Me) is 55.56 and the mode value (Mo) is 56.61, 67, 72 and the standard deviation value is 6. For more details, see the following data:

Table 6. Student Learning Outcomes Using Augmented Reality learning media based on Discovery Learning

Class	Interval Class	F. Absolut	F. Relatif %
1	17-26	1	3,33
2	27-36	2	6,67
3	37-46	6	10,00
4	47-56	7	23,33
5	57-67	8	26,67
6	68–77	6	20,00
	TOTAL	30	100

The analysis requirements test performed is the normality and homogeneity tests. Testing was carried out using the Liliefors test. A summary of the normality of the two samples can be seen in Table 7 below:

Table 7. Summary of Data Normality Test with Liliefors

No.	Data	Class	L_{count}	L_{table}	Conclusion
1	Post-tes	Class XI student learning outcomes on the circulatory system using Augmented Reality learning media based on Discovery Learning	0,083	0,161	Normal
2		Class XI student learning outcomes on the circulatory system without using Augmented Reality learning media based on Discovery Learning	0,069	0,161	Normal

Thus the pre-test values for the experimental class and control class Lcount < Ltable, while the post-test values for the experimental class and control class Lcount <Ltable, it is synthesized that the two sample group data are normally distributed.

Homogeneity test analysis using the F test is to prove the largest variance and the smallest variance with the formula:

$$F = \frac{Varian\ terbesar}{Varian\ terkecil} = \frac{S_1^2}{S_2^2}$$

A summary of the homogeneity of the two samples is seen in Table 8 below:

Table 8 Summary of Data Homogeneity Test

No.	Data	Class	F_{count}	F_{table}	Conclusion
1	Post-test	Class XI student learning outcomes on the circulatory system using Augmented Reality learning media based on Discovery Learning	0.078	1.080	Homogen
2		Class XI student learning outcomes on the circulatory system using expository-based Augmented Reality learning media			

So it can be seen that Fcount <Ftable at a significant level of α = 5% states that the data of the two samples have a

homogeneous variance and it can be concluded that the research data meets the requirements for hypothesis testing.

Hypothesis testing uses the t-test with the formula, namely:

$$t = \frac{\bar{x}1 - \bar{x}2}{s\sqrt{\frac{1}{n1} + \frac{2}{n2}}}$$

The following is the formulation of this statistical hypothesis, namely:

Ho   : $\mu A1 \leq \mu A2$
Ha   : $\mu A1 > \mu A2$

Information:

$\mu A1$: average student learning outcomes taught using Augmented Reality learning media based on Discovery Learning

$\mu A2$: average student learning outcomes taught using expository-based Augmented Reality learning media

The t-test is used as a hypothesis-testing tool because the research data is normally distributed and homogeneous. The hypothesis in the research is:

Ho: Augmented Reality Learning Media based on Discovery Learning is not effective in improving Biology learning outcomes.

Ha: Augmented Reality Learning Media based on Discovery Learning effectively improves Biology learning outcome

From the results of testing the hypothesis obtained t count = 1,699 and t table 2,045 so that t count = 1,699 < t table 2,045, so that H0 is accepted, it can be concluded that there is a significant difference in the learning achievement of class XI students using Augmented Reality learning media based on Discovery Learning on the circulation system blood compared without using Augmented Reality learning media based on Discovery Learning.

3.2 Discussion

Augmented Reality learning media products based on Discovery Learning on the circulatory system were developed through the student trial stage and the validation stage of material experts and learning media experts and with product revisions that have been carried out based on the advice of experts, students, and teachers, Augmented learning media products are produced Reality-based Discovery Learning on the circulatory system that is feasible and effective for students and teachers to use in the learning process for high school class XI students. This is also in line with the results of Mauludin's research [24], conducting research on the effectiveness of Augmented Reality learning media products which shows that the Android version of the Augmented Reality application is considered attractive and acceptable to students and teachers as an alternative learning media for the human excretory system, as well as being effective. in assisting the learning process of biology in class.

Using this product will greatly assist teachers and students in understanding the material in the learning process. The advantages of this learning media product are (1) Displaying 3D object images on the organs displaying the structure of the human body, namely the circulatory system in the form of red blood cells, white blood cells, blood vessels, and especially the 3D view of the heart organ. and displays the circulatory mechanism of the circulatory system. (2) In addition to seeing 3D views and images as if they were real, it provides an interesting learning experience for students. And according to the results of Qumilaila's research [25] the opportunities for Augmented Reality to be accessed by the community including students are open. (3) The material for this learning media product also links the circulatory system material with the Discovery Learning learning method so that it stimulates students' analytical thinking skills to make their conclusions from the material that has been obtained. According to Khasinah [26] that the Discovery learning method is an active learning style, that learning must be done while doing or learning by doing. And in the research process, students tend to study actively and have group discussions after using Discovery Learning-based Augmented Reality learning media. (4). Learning is independent so learning tends to be Student-Centered Learning (focusing on student activity).

According to the research results of other researchers, Widyaningsih & Wulandari [27], Ainni & Budi [28], Lauryn [29] & Mauluddin [30], the use of Augmented reality as a learning medium can help students to understand concepts and theories, stimulate students to think conceptual and feel 3D, improve the image (representation and perception, create an interactive and attractive and more fun learning atmosphere). From the results of this study, it is evident that Discovery Learning-based Augmented Reality learning media products in the circulatory system is feasible and effective and are used as learning media that can help students understand concepts and theories, stimulate students to think conceptually and experience 3D learning to improve the picture in thinking and create an interactive and attractive learning atmosphere and fun.

Discovery Learning-based Augmented Reality learning media products in the circulatory system are products that are effectively used based on evidence of analysis of student learning outcomes in the control class and experimental class. It was found that the experimental class that used Discovery Learning-based Augmented Reality learning media on the circulatory system had higher learning outcomes than the control class that did not use Discovery Learning-based Augmented Reality learning media products on the circulatory system. In addition, effectiveness is also evidenced by an assessment of student responses showing a motivated attitude and providing a fun, active, and innovative learning experience. Data analysis was also carried out in testing the effectiveness of Augmented Reality learning media products based on Discovery Learning on the circulatory system fulfilling the criteria for effective use which is shown from the results of product effectiveness testing using the t-test on different independent test tests. The average value of the two groups of students, namely the control class and the experimental class, was then tested with the t-test [31]. The average result of the assessment in the experimental class was that the average score of the learning outcomes test was higher than the average result of the control class students who did not use learning media.

4. CONCLUSION

Augmented Reality learning media based on Discovery Learning on the circulatory system is very suitable to be used as a learning resource in learning material for the Circulatory System Class XI SMA. This feasibility has been assessed and validated by experts in their fields, namely material experts and learning media experts, and then with suggestions from experts, revisions to learning media products are carried out to produce better and ready-to-use products. In addition, the teacher's assessment of the biology study of the learning

media products developed was followed by product revisions according to suggestions. Based on the trials of class XI students at SMA Plus Sedayu Nusantara in individual trials, small group trials, and large group trials which were carried out, the results of this product were very feasible to use and developed to increase student learning outcomes, strengthen discussion learning (student-centered learning), to conclude (Discovery Learning), and improve students' thinking skills.

Augmented Reality learning media based on Discovery Learning on the circulatory system is very effective to use. This is evidenced by the assessment of student responses showing a motivated attitude and providing a fun, active, and innovative learning experience. In addition, in testing the effectiveness of Augmented Reality learning media products based on Discovery Learning in the circulatory system, it meets the criteria for effective use, which is shown from the results of product effectiveness testing using the t-test on different independent test tests. The average result of the assessment in the experimental class was that the average score of the learning outcomes test was higher than the average result of the control class students who did not use learning media.

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