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Development of Augmented Reality Media to Improve Student Understanding of Optical Eyes System Materials

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Abstract: Optical material is material that is quite difficult for students because it has abstract concepts. Media that is considered an alternative solution is augmented reality. AR provides an effective learning experience because it displays 3D images so that it is easily accepted by students and makes students interested in learning. This study aims to develop augmented reality media to increase students' understanding of the eye optical system material. The type of research to be carried out in Research and Development, with the chosen development model being ADDIE. Product evaluation is carried out based on test results and product implementation. The population of this research is students of the Physics Education Study Program, FKIP UT, who are enrolled in the 2021.2-semester lectures and tutors for the Physics Education Study Program, FKIP UT. The research sample was students of the UT FKIP Physics Education Study Program who attended several 18 people (from UPBJJ UT Bogor, Jakarta, and Serang and tuweb tutors for the optics course). The data collection method consisted of administering a questionnaire. To determine the level of understanding of student material on system material eye optics, test results given to students were analyzed descriptively. Questionnaire analysis from tutors and students regarding the need for AR media was analyzed descriptively and quantitatively. The sampling technique used was random sampling, in which the entire population has the same rights and opportunities to be involved in research Based on the results of the needs analysis, it shows that 81% of students agree and need AR media to study the optical system of the eye, 72% of students agree that the material for the optical system of the watch has the potential to cause misconceptions if studied without using media. Based on the results of the needs analysis, consists of 3 main topics, namely regarding the structure of the eye, the process of seeing in the eye, and eye defects. The results of the trial analysis using AR media used a paired sample t-test to see the effectiveness of AR media. The results of the analysis of the paired sample t-test showed a Sig.2 tailed value > 0.05 so it can be concluded that there was a significant difference between before and after using AR media. In other words, it is easier for students to understand the material after being treated in the form of AR media on the concept of eye optics.

Keywords: Augmented reality; Eye system; Learning media; Optics

Introduction

Physics emerges and develops through observation, problem formulation, hypothesis formulation, hypothesis testing through experimentation, drawing conclusions, and theory/concept discovery (Santrock, 2011). Physics has three scopes, namely as a product, as a process, and as an attitude (Chanafi et al., 2016). Physics as a product is a collection of knowledge consisting of facts, concepts, theories, principles, and models. Physics as a process is a skill possessed by scientists to produce products while attitudes are behaviors based on the beliefs possessed by

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scientists in the process of producing products. Physics learning should pay attention to the Nature of Science as a process, product, and attitude (Zakirman et al., 2020).

Physics is a subject that requires an understanding of concepts that are hierarchically interconnected (Supardi et al., 2015). Theories contained in many Physics materials contain abstract concepts. For example in optical materials. Optical material is material that is quite difficult for students (Khusna et al., 2016). Students consider that Physics lessons are very saturated so it seems that Physics makes students passive in the learning process, and this greatly affects the results of the learning obtained.

Distance learning is a form of learning implemented at the Universitas Terbuka using an asynchronous pattern. Asynchronous online learning shows that students will experience meaningful learning when they are in a participatory learning environment (Jena et al., 2019). This environment is intentionally designed to help participants develop a sense of community to give them the opportunity to engage in collaborative discussions. This interaction encourages participants to actively build new meanings related to the material (Perveen, 2016). This is in line with the nature of learning Physics, which should be based on constructivism. Constructivism as a basis in learning has the premise of 1) knowledge is constructed by students, 2) prior knowledge has an impact on learning, 3) knowledge construction requires activities that have goals and efforts, and 4) initial understanding of a concept is derived from the contextual environment. Constructivist physics learning is expected to make students actively involved and become the center of learning and learning activities assisted by the teacher. Students in constructivist learning try to acquire new knowledge based on existing knowledge through active mental activities (Malik et al., 2017). However, learning Physics remotely has various difficulties and obstacles. Among them is still low student understanding related to Physics material.

Based on the results of the initial needs analysis carried out through observation and interviews, shows that optical material, especially in the eye system, is difficult for students. This is because the optical material in the eye system contains abstract and complex concepts. In addition, misconceptions also often occur if asynchronous teaching is carried out without adequate media support. Previous research showed that there were 58.15% misconceptions about eye system materials (Munawaroh et al., 2018). Other research shows that learning difficulties identified include students' difficulties in experimenting with optical devices, difficulties in learning optical devices in class and outside the classroom, difficulties in understanding the application of optical devices in everyday life, and students' difficulties in solving problems mathematically (Ainiyah et al., 2020).

Learning Physics means trying to get to know real-life processes, so the teaching needs to be delivered with the right media so that learning goals can be achieved (Zakirman et al., 2017). Several studies have shown that media has been developed to teach optical material. Research conducted by Sudibjo (2019) shows that the development of Google Classroom-based media on the subject matter of Optical Devices is feasible for use in learning. However, teaching with Google Classroom has weaknesses, so it is necessary to form study groups as discussion groups in class or at home (online) to make it easier for students to learn (Sudibjo, 2019). In addition, other research shows that the use of physics learning media with e-learning based on Edmodo Blog Education can help students to improve student learning outcomes in the cognitive aspect, not only seen from students' cognitive abilities but also must pay attention to students' affective and psychomotor abilities. Because students who have high cognitive learning outcomes do not necessarily have good communication skills (Sudibjo et al., 2013). Other research shows that the use of contextual-based knowledge enrichment books on optical material is appropriate as a learning medium and can increase students' knowledge. However, book media is still too rigid so many students are still confused about understanding abstract material (Rofiah et al., 2015). Thus it can be understood that the media that has been developed before is still not optimal to support the teaching of optical material.

As an alternative solution to this problem, Augmented Reality (AR) media was chosen. Augmented Reality is an innovation where AR technology has the ability to project computer graphics into the real world (Ramadhanti et al., 2021). AR differs from Virtual Reality (VR) in that in VR people are expected to experience a computer-generated virtual environment. In AR, the environment is real but extended with information and images from the system. In other words, AR bridges the gap between real and virtual in a subtle way (Lee, 2012).

AR provides an effective learning experience because it displays 3D images so that students can easily accept them and make students interested in learning (Mustaqim, 2010). The material for the eye system contains various abstract concepts such as the parts of the eye and their functions, eye diseases/abnormalities, how shadows are formed so that the process of seeing occurs, and so on. This abstract concept can be explained in detail using AR. AR technology is considered suitable for use in optical materials. In addition, the results of the initial needs analysis show that students still experience misconceptions about asynchronous teaching in eye material so they need appropriate and adequate media

to facilitate their understanding. Thus, AR technology was chosen as an alternative solution to the problem of remote optical teaching.

Method

The type of research to be carried out in Research and Development, with the chosen development model being ADDIE. The purpose of this study was to develop augmented reality media to increase students' understanding of the eye optical system material. The ADDIE development model begins with Preliminary Analyze/analysis activities (needs analysis, including analysis of media needs in terms of the user aspect, suitability with the curriculum, and strengthening using literature review), Product Design/design (designing products based on the results of needs analysis), Develop/developing products (covering assessment activities by experts), implementation (small scale and large scale trials) and evaluation as a form of the final assessment of research products (Trust et al., 2018). The research floes can be seen in Figure 1.

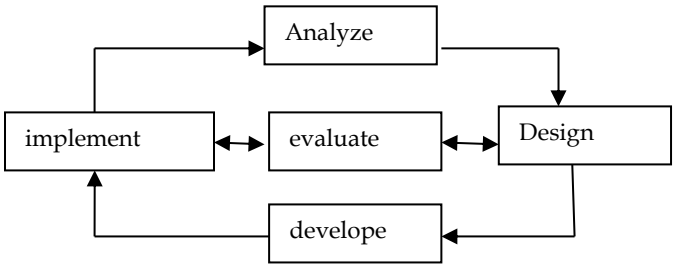

Figure 1. ADDIE research model flow

This research was divided into three stages the research year, where the first year of the research and analysis of prototype requirements and initial product design was carried out. In the second year of research activities to be carried out are product development including product testing by experts. The third year is the year of product implementation and evaluation prior to dissemination. In this third year, the product is being tested on a small and large scale. Product evaluation is carried out based on test results and product implementation. The research population in this first year are: a) Students of the Physics Education Study Program FKIP UT who are enrolled in the 2021.2-semester lectures; b) Tutor tuton of the Physics Education Study Program FKIP UT. The research samples were: a) 18 students from the Physics Education Study Program FKIP UT who took part (from UPBJJ UT Bogor, Jakarta, and Serang); b) Tuweb tutor for optics courses. The data collection method consists of administering a questionnaire. To determine the level of students' understanding of the material on the optical system of the eye, the test results given to students were analyzed descriptively. Questionnaire analysis from tutors and students on AR media needs was analyzed descriptively and quantitatively. The sampling technique used is random sampling, in which the entire population has the same rights and opportunities to be involved in this study.

Result and Discussion

The development of AR media in 1st year is the initial stage in the implementation of development research. The year I was the year of Preliminary Research where at this stage data and information were collected from respondents related to research problems and product designs that were to be developed according to user needs (Analyze and Design). Research activities in the year I aim to produce AR media designs on the concept of eye optical systems. The target of research activities in the year I is to produce AR media designs that suit the needs of users, both students and tutors. A needs analysis was carried out by involving respondents, namely students and tutors. Needs analysis needs to be carried out by involving respondents, namely product users so that the AR media produced is in accordance with their needs. Needs analysis data from the student side is obtained by providing an instrument in the form of a student's conceptual understanding test on the optical eye system material which consists of 10 questions. Furthermore, students were also asked to fill out a questionnaire related to the analysis of material characteristics and media needs in the material in the optics course. The tutors involved in the needs analysis stage are tutor tutors who have taught optics courses. The questionnaire given to the tutor contains several questions including the tutor's perception of the abstractness of the material, the complexity of the material, and other questions that support the development of AR media.

The needs analysis involved 18 students from 3 UPBJJ namely Serang, Bogor, and Jakarta. The initial activity carried out was to provide questionnaires and test instruments to see the level of students' understanding of the material on the optical system of the eye. The questionnaire distributed aims to see the extent to which AR media is needed according to student perceptions. The questions given include the abstractness of the material, the complexity of the material, the percentage of achievement of learning objectives, the difficulty of the material, and the need for media in the material. The next activity is giving questions with the type of choice and equipped with reasons for choosing the answer options. The items

given were 10 items related to understanding the concept of the optical system of the eye. Data were analyzed descriptively and the results obtained were analyzed and used as material for consideration in developing AR media on the concept of eye optical systems.

Analysis of the Characteristics of the Material and Content (curriculum) in the Optics Course According to Student Perceptions

To find out the level of students' understanding of the eye optical system material, a test is given which consists of 10 questions. The results of the curriculum analysis of the eye optics system material can be seen in Figure 2.

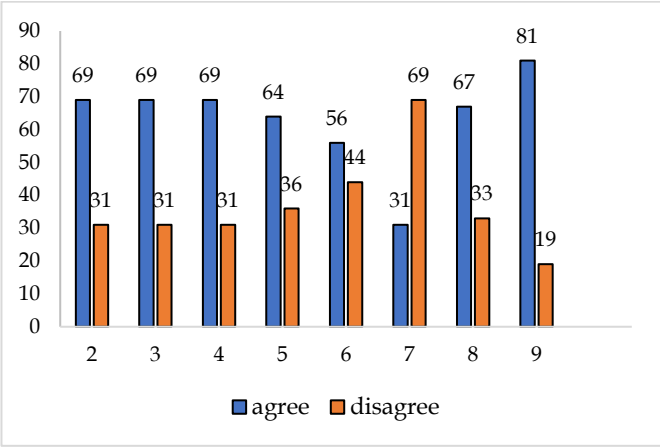

Figure 2. Results of curriculum analysis and AR media needs by students on eye optical system material

The findings on curriculum analysis based on student perceptions can be concluded that the material for the optical system of the eye has material characteristics that have the potential to cause misconceptions. Presentation of optical material also requires a lot of demonstrations and visualizations that require complex tools and equipment and are often difficult to use in learning for various practical reasons (Cai et al., 2021). To project the path of light such as the process of forming shadows on the eye, to recognize the structure and parts of the eye, we need a media with AR type. AR media can be a medium that helps students to make it easier to understand material on the optical system of the eye, increase the percentage of achievement of learning objectives and help understand the material that is abstract in nature (Bond et al., 2020). In summary, Augmented Reality (AR) bridges real conditions and is digitally visualized (Pegrum, 2021; Czerkawski et al., 2021). The use of AR media also makes it easier for students to understand the differences in eye defects such as nearsightedness, farsightedness, and astigmatism.

Understanding of Student Concepts in the Material of Eye Optical Systems

Based on the results of the analysis that has been carried out on student perceptions regarding the characteristics of the material in the optics course, it can be concluded that some material such as in module 3 in KB 2 regarding the optical system of the eye is still difficult to understand, and requires visualization to understand the material, namely AR media. In various research, AR has been used in various fields including education, medicine, pilot training, engineering, and others (Yilmaz, 2021). The use of Augmented Reality media has the potential to increase the efficiency of learning and reduce misconceptions in understanding material (Febrianti et al., 2017). Referring to the analysis of student material comprehension test results on the concept of eye optical systems, it was found that the average student score was 53.3. If converted into a final assessment, the average grade is at an unsatisfactory level. Following up on these findings, suggestions, and input from students in the optics course are as follows: 1) Visualization needs to be added to clarify understanding of material concepts, 2) AR media is needed to make eye system material more concrete.

Tutor

The product in the form of AR media which was developed on the eye optical system material has a target prospective users, namely students and tutors. Needs analysis was not only carried out on students but to see the importance of developing AR media needs analysis was also carried out with tutor respondents. Based on the results of the analysis, it can be concluded that the eye optical system material has the potential to cause misconceptions according to the tutor's perception. The optical system of the eye with material details such as the structure and parts of the eye, the process of seeing in the eye, and eye defects is an abstract concept that requires visualization according to the tutor's perception. Recognizing the structure and function of the eye can not only be done by implementing audiovisual media but requires AR media so that the material can be conveyed properly. Augmented reality (AR) technology has the potential to simulate real-life situations and create authentic learning (Buesing et al., 2013).

Before the AR media product in the eye optical system concept is ready to be validated and tested, several stages of activity are carried out. FGD is an initial activity to equalize perceptions between researchers, experts, and product developers to get the appropriate product quality. FGD activities are important activities to evaluate and check the progress of the development of AR media products on a regular basis. Focus group discussion is a discussion activity in presenting resource

persons to provide input and provide guidance in the development of AR media on the material of the optical eye system. The FGD activities in the research in the year I was carried out 3 times by presenting expert speakers in the field of AR.

Suggestions and input in the FGD session were also related to the material content contained in the storyboard. Theoretical suitability between the structures of the eye parts is noted in the preparation of storyboards for AR media. The design of the shape and color of the eyes was revised again after receiving input from the FGD session I. In addition to content, technical matters such as instructions for use were also points of improvement for the storyboard. The focus of the second session of the FGD was the study of material, especially on the structure of the eye. The initial view of the eye required several revisions and refinements. The purpose of making this AR media is to prevent misunderstandings about eye material. For this reason, an in-depth study of the shape and structure of the eye is needed. Improvements to the eye design made by the development team include the shape of the eye, the inner color of the eye, the emphasis on the conjunctiva, and the clarification of the color of the cornea. When all parts of the eye are suitable, then the product development team continues the process of working on the product in the process of vision in the eye and eye defects. Session III of the FGD was the final activity before the AR media product on the optical eye system concept was tested. Suggestions and input in the third session of the FGD focused on content and material related to the process of vision in the eye and eye defects. The visualization contained in AR media must be equipped with the process of the passage of light/light so that students become more aware of both the process of vision and eye defects. The completeness of the material contained in the AR media also became suggestions and input for the third session of the FGD activities. Furthermore, AR media was developed by taking into account the suggestions from the FGD. The appearance of AR media on the concept of the developed eye optical system can be seen in Figure 3.

Figure 3 shows the parts of the eye and is equipped with explanatory information for each part of the eye. As seen in the example image, this section shows the sclera, where the position of the sclera is visible in the structure of the eye, and information regarding the sclera appears. The same thing will apply when you click on another part of the eye, information about the highlighted part will appear. The part of the eye shown in the AR shape can be rotated and rotated 360°. This can be done by touching the eye and then scrolling or rotating using the help of a finger on the smartphone screen. All parts of the eye structure can be clicked by the user, besides that complete information about the part is provided on the same layer. In this material menu, there is no access time limit. This means that each user is free to determine their own study time, without having to rush with the time set by the application (Yilmaz, 2021). This kind of convenience accommodates the diversity of student abilities in understanding the material.

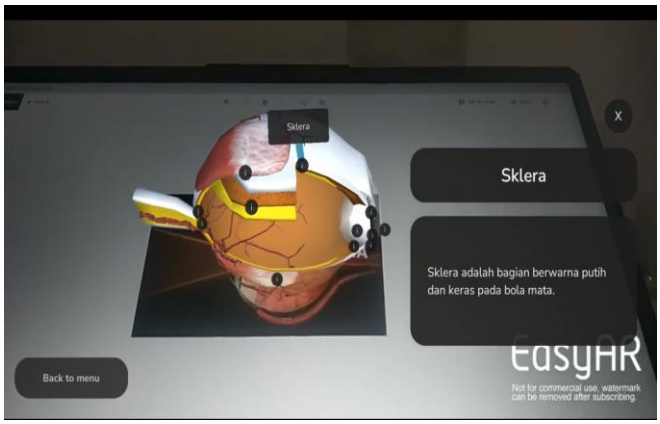

Figure 3. Display of the parts of the eye contained in AR media in the concept of the eye optical system

Furthermore, trials were carried out to determine the effectiveness of using AR media on the concept of the eye optic system. The trial was conducted on 21 students as respondents. Then students were asked to fill out a questionnaire related to media presentation, material aspects, and product practicality. The test results can be seen in Figure 4.

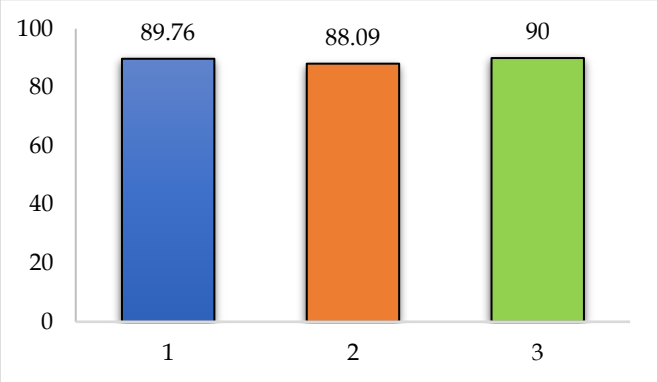

Figure 4. Results of the analysis of student trials on the use of AR media on the concept of eye optical systems

In Figure 4, it can be seen that the assessment of media presentation is at a score of 89.76. The points assessed in the presentation of the media can be seen in Figure 5.

Based on Figure 5, it can be seen that the highest score was given by students for AR media points that are easy to operate, audio-visual components are easy to understand, as well as audio and visual according to the topic. Furthermore, material assessment points can be

seen in Figure 6. Based on Figure 6, it can be seen that the highest score was given by students for image accuracy points. For concept accuracy, color and material have the same score of 87.6. Furthermore, the practicality assessment points for AR media can be seen in Figure 7.

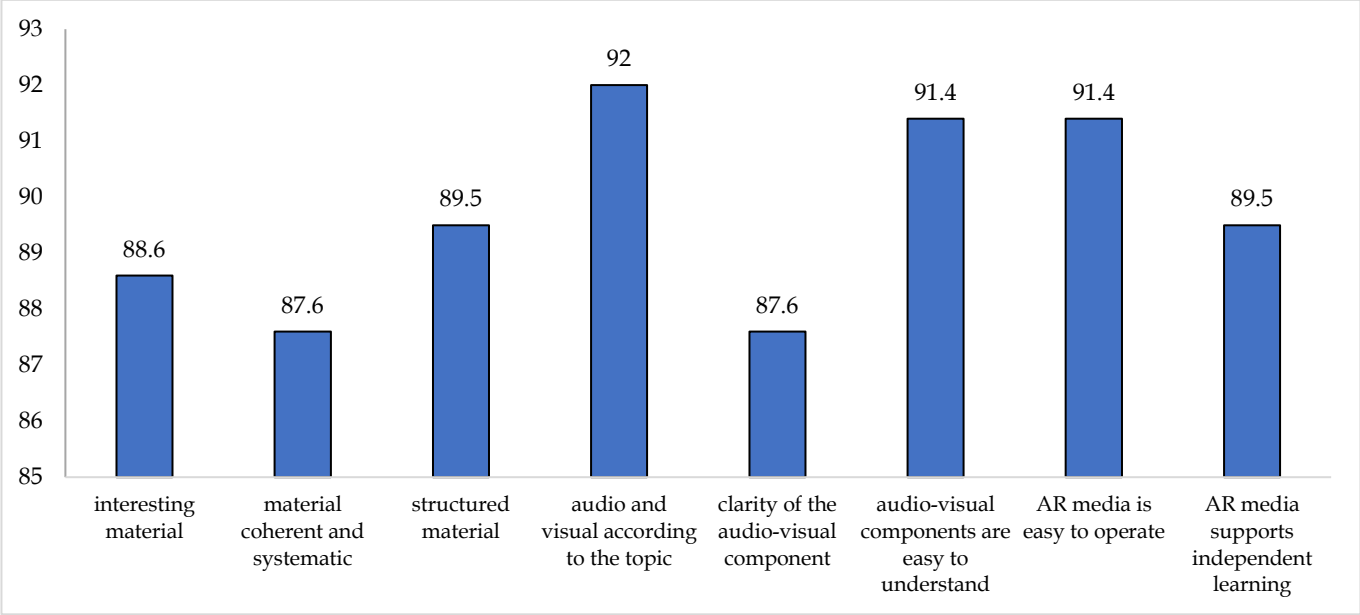

Figure 5. The results of the analysis of the assessment of media presentation

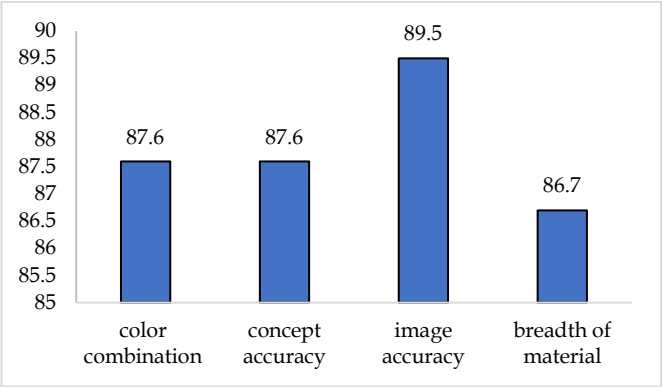

Figure 6. Results of the analysis of the assessment of the material

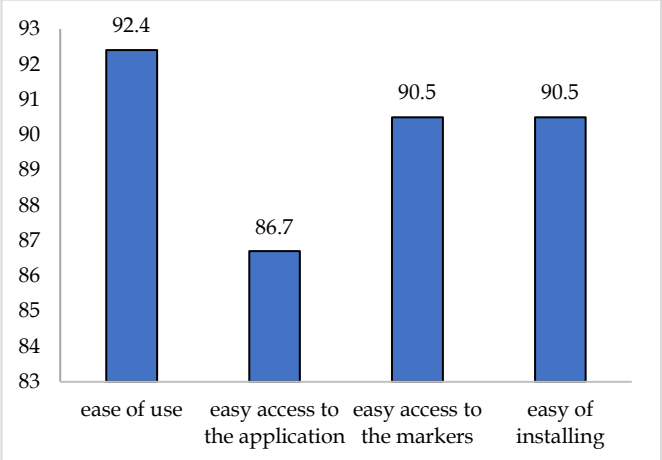

Figure 7. The practicality analysis results of AR media

Based on Figure 7, it can be seen that the highest score was given by students for ease of use points. For points of ease of installing and accessing markers it has the same score of 90.5, for ease of accessing the application it has a score of 86.7.

Furthermore, to test the effectiveness of AR media on the concept of an eye optic system, a pair sample t-test was carried out. The tests are given in the form of pre-test and post-test where the questions are already in the AR media. Then do the normality test and homogeneity test. The results of the normality test can be seen in Table 1.

Table 1. One-Simple Kolmogorov-Smirnov Test

		Pre Value	Post Value
N		21	21
Normal Parameters*	Mean	5.57	7.19
	Std. Deviation	1.076	.928
Most Extreme Differences	Absolute	.226	.343
	Positive	.202	.343
Kolmogorov-Smirnov Z	Negative	-.226	-.226
Asymp Sig. (2-tailed)		1.037	1.573
		.233	.014

Based on Table 1, it can be seen that the value of Sig.2 tailed > 0.05 so the data is normally distributed. Then the homogeneity test can be seen in Table 2. Based on Table 2, it can be seen that the value of Sig.2 tailed > 0.05 so the data is homogeneous. Then a paired sample t-test was carried out to see the effectiveness of AR

media. The results of the analysis of the paired sample t-test can be seen in Table 3.

Table 2. Test of Homogeneity of Variances Value

Levene statistic	1.115
df1	1
df2	40
Sig	.297

Table 3. Results of Paired Sample T-Test Analysis

Pair 1 Value - Categori			
	Paired Differences		
	Mean		4.881
	Srd. Deviation		1.041
	Std. error Mean		.161
	95% confidence internal of the difference	lower	4.557
		upper	5.202
t			30.395
df			41
Sig. (2-tailed)			.000

Based on Table 3, it can be seen that the value of Sig.2 tailed > 0.05 so it can be concluded that there is a significant difference between before and after using AR media. This shows that it is easier for students to understand the material after being treated in the form of AR media on the concept of eye optics. The use of AR media also contributes to increasing student involvement (Tomara et al., 2019).

Conclusion

The results of the needs analysis that was carried out in the early stages of this research indicated that some of the material included in the learning activities had the potential to cause misconceptions, requiring visualization and AR media to be studied. The material in question is contained in module 3, namely KB 2 regarding the optical system of the eye. Based on the results of data analysis regarding student responses to the eye optical system material, as many as 81% of students agreed and needed AR media to study the eye optical system. As many as 72% of students agreed that the material for the optical system of the eye would potentially cause misconceptions if studied without using media. Therefore it is very necessary to develop AR media on the concept of eye optics systems to support the learning process in optics courses. The AR media product design developed based on the results of the needs analysis consists of 3 main topics, namely regarding the structure of the eye, the process of seeing in the eye, and eye defects. The results of the trial analysis using AR media used a paired sample t-test to see the effectiveness of AR media. The results of the analysis of the paired sample t-test showed a Sig.2 tailed value > 0.05 so it can be concluded that there was a significant difference between before and after using AR media. In other words, it is easier for students to understand the material after being treated in the form of AR media on the concept of eye optics.

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