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Development of Learning Media Based Augmented Reality Electromagnetic Induction Subject Matter

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ABSTRACT

Learning about electromagnetic induction in physics calls for a deeper comprehension of abstract ideas and ways of thinking. This article is part of a development research project on augmented reality-based learning materials focused on electromagnetic induction. Its goal is to assess the reliability and efficacy of augmented reality-based learning materials with a particular emphasis on the cognitive learning outcomes of students. The 4-D development model "Define, Design, Develop, and Disseminate" is used in the study. (1) It is extremely practical to apply learning media based on augmented reality electromagnetic induction subject matter. (2) As a result of trials carried out based on the outcomes of a mean N gain of 0.76, the cognitive learning outcomes of students improved. The independent t-test findings revealed a significant relationship between the two variables, with a significant 2 tails of 0.000 (3). Student replies revealed that the learning medium are extremely practicable to use, with an average percentage value of 87%. This research has an update in the use of augmented reality-based learning media for physics ideas that require high-level knowledge and abstract thinking.

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INTRODUCTION

Technology is currently growing rapidly in various fields. Some of them are political, social, cultural, information, transportation and education. In the field of education, there are currently many media, information and communication technologies that are very helpful for the teaching and learning process. According to Putra (2018), technological developments over time always experience significant changes. The emergence of new technologies, in line with the increasing variety of technologies based on electronics technology. the introduction of new technologies to keep up with the growing range of electronics-based technologies.

The Covid-19 virus, which started a pandemic in 2020, forced everyone to carry out their daily tasks at home, including schoolwork. In learning during the Covid-19 outbreak, the role of technology is needed (Khotimah et al., 2019). This is the basis on which many people want to further develop technology in the field of education, by increasing technology-based learning media and can be accessed via the internet or not directly. According to Nurrita (2018), learning media is a tool that can facilitate the teaching and learning process in order to make it easier to transmit explanations and achieve learning objectives. Audi (2019), suggests that "learning media can improve the intellectuality of students and be able to build new knowledge as an effort to increase good supervision of learning material, so that it becomes a conducive learning area where recipients can carry out learning efficiently and effectively".

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Literature Review

Related to this, researchers are interested in making learning media based on augmented reality as a technology development for existing learning media. Ramadhan et al. (2021) put forward augmented reality as a technology that can combine the real world with the world in 3D form. According to Wahyudi (2019), states that augmented reality can improve students' visual spatial intelligence in the learning process.

Then a thorough literature review was carried out by examining previous actual literature publications to find out the relationship related to augmented reality. From figure 1, the author tries to provide an overall picture of the trend of augmented reality research based on Google Scholar data from 2018 to 2023 as an initial research conducted by the author. There are five important categories in AR research: AR development refers to studies (red color) system review (green color) industry (yellow color) (blue color) reality application (purple color).

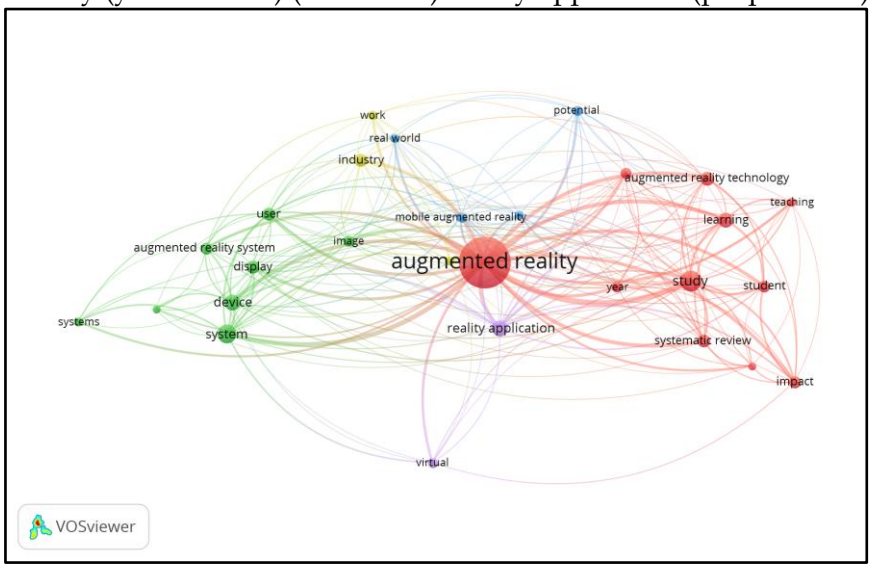

Figure 1. Reaserch augmented Reality based google scholar database

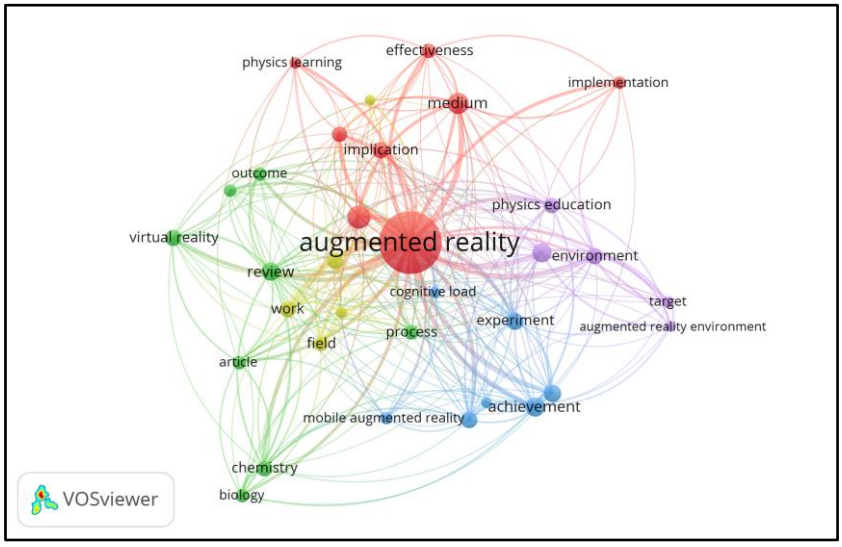

Figure 2. Augmented reality relating to physics goals and outcomes

Based on Figure 2. bibliometric analysis with the keywords "augmented reality, physics, impact, goals" were constructed and visualized using the VOSviewer software tool. There are many AR implementation studies for physics learning that focus on effectiveness, learning outcomes, cognitive load. This analysis is the author's idea to develop and create new things in learning media to get electromagnetic induction cognitive learning outcomes.

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It is hoped that learning using these media can increase students' interest in and visual understanding of physics learning material, especially in electromagnetic induction subject matter which requires lots of illustrations in its delivery. In this way the researchers conducted a study entitled "Development of Augmented Reality-Based Learning Media to Improve Cognitive Learning Outcomes of Electromagnetic Induction subject matter." The purpose of this research is to determine the validity and effectiveness of using Augmented Reality-based learning media that focuses on cognitive learning outcomes of students in learning activities of electromagnetic induction subject matter. This can make it easier for students in the learning process and so that students can remember subject matter and concept in a creative way.

RESEARCH METHOD

This study is classified as *Research and Development* (R&D) based on problem formulation and aim of the research which will result a learning media using augmented reality basis and will be categorized as quantitative research. According to Ramadhan (2019), stated that quantitative study is used for examining sample utilize instrument which produce data to be analysed with statistic descriptive.

Population in this study is all the students of twelfth grade in a certain high school in Surabaya. According to Sugiyono (2017), sample is a subset of the number and characteristics of population. The sample technique that is used by researcher is Probability Sampling (simple sample) where each of the population has the same chance of being selected as a randomly determined sample. In this case, the sample that will be used is XII Sains 1 class, the number of samples was known to be 31 students.

Development Model

The development model utilizes a 4-D development method consisting of 4 step in order to produce a final product that is ready to be implemented in learning in educational units namely: Define, Design, Develop and Disseminate (Haryadi, 2018).

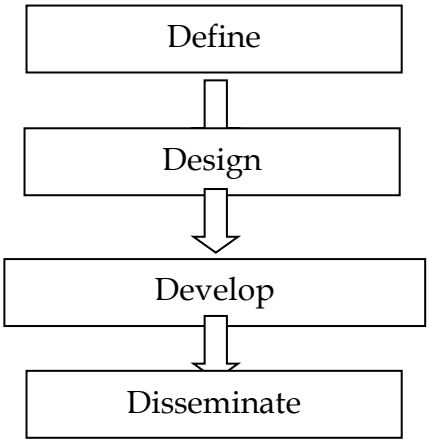

Figure 3. 4-D Development Model

The define step is the definition related to development requirements to determine the product to be developed. Activities can be in the form of a study of previous research literature. The design step is the design activity for the product that has been determined to be developed. The develop step is the stage to produce a product with several steps until a valid product is produced. Then carry out the disseminate step, namely the final step in the form of disseminating valid products to respondents. At the develop step, this research develops augmented reality media with the following step.

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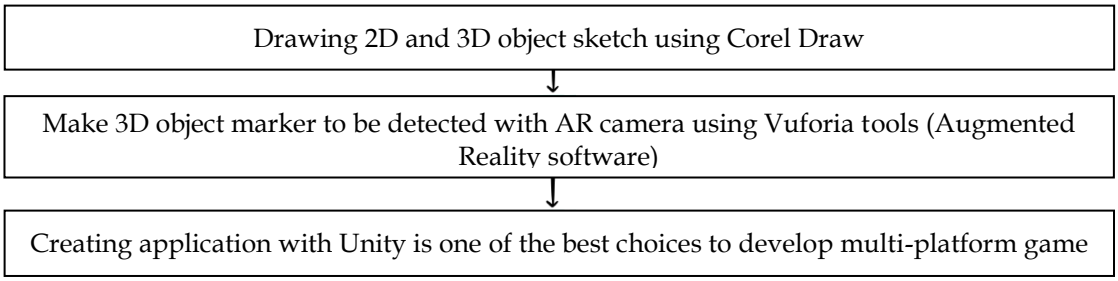

Figure 4. The "Develop" Step of Augmented Reality Media Development

Development Procedure

Based on the of the development model, learning media development has been carried out using the 4-D development model. The following describes the steps of developing augmented reality-based media electromagnetic induction section.

Define: the stage where the researcher creates AR-based learning media after analyzing previous research by means of bibliometric analysis. This analysis is to find out how the media concept will be made.

Design: the stage where the determination of learning media objectives is made to improve the cognitive learning outcomes of students. Then design AR-based learning media such as determining colour concepts, electromagnetic induction learning materials that will be loaded in the application, and application template designs.

Develop: the stage of realizing the design of the application that has been made. Then, ask validation to two expert validators. It is possible that there will be several revisions to the suitability of the material with the developed media until it becomes valid and suitable media for use.

Disseminate: the stage of dissemination and use of AR basis learning media for Electromagnetic Induction subject matter to research subjects. This stage is in the form of research on the media using pre-test, post-test sheet instruments and student response questionnaires and will be analysed using n-gain values.

Interface Design

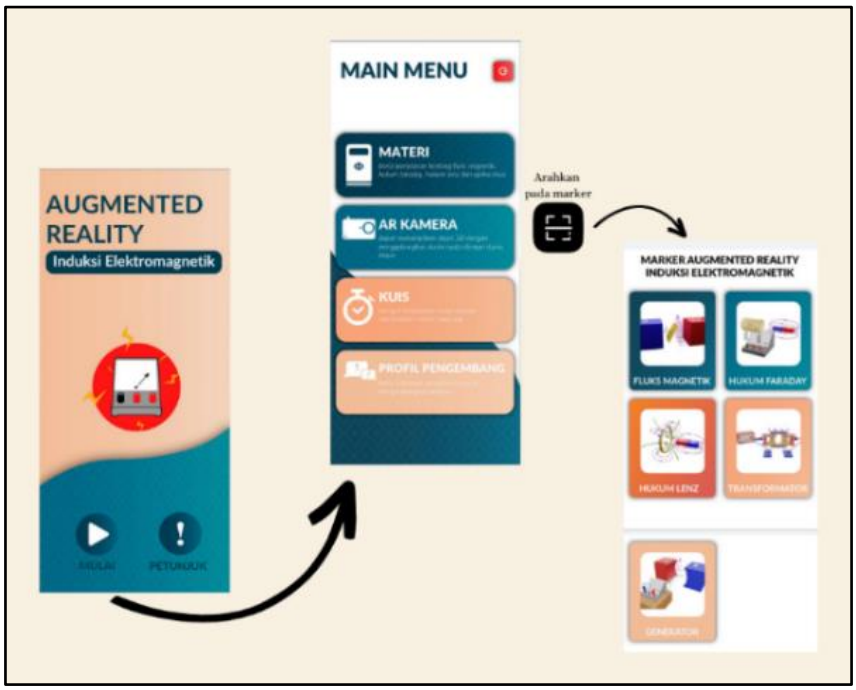

Figure 6. Interface Design

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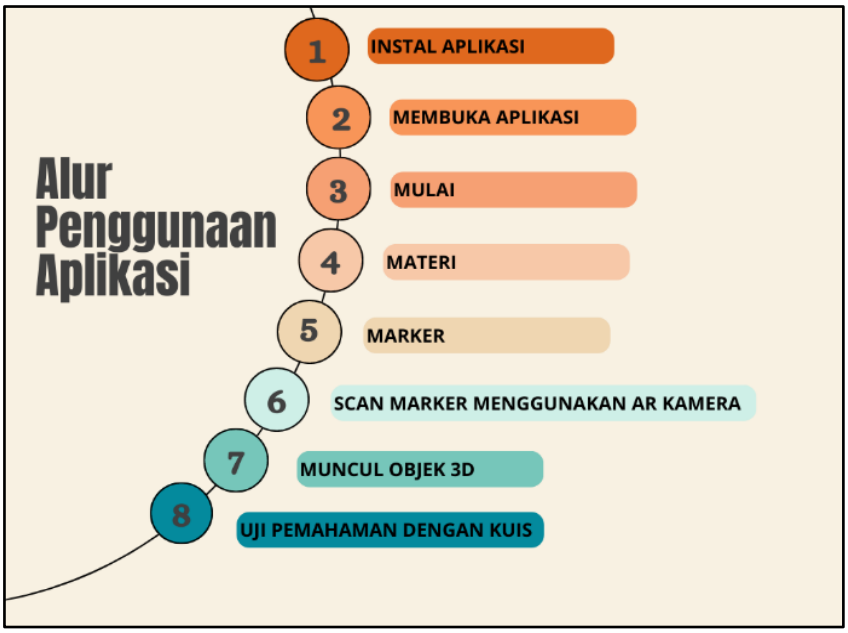

Figure 7. Procedures of Using Augmented Reality-Based Application on Electromagnetic Induction Subject matter

Meanwhile, Figure 7. explains that the procedure for using the Electromagnetic Induction AR application is very easy; After logging in and starting the application, four options will appear containing study material, AR camera, quiz and development profile, presented in Figure 6. On the study material platform, it contains an explanation of each subchapter of electromagnetic induction. On the AR platform, the camera will appear to be directed at a marker that will later be read by the application to bring up 3D animated objects on the smartphone screen.

Data Retrieval Technique

By administering instruments in the form of pre-tests, post-tests, and questionnaires, data gathering techniques are carried out. According to (Sugiyono,2017), questionnaire is a data collection technique by providing a device in the form of a written statement for respondents to answer.

Data Analysis

Determination of response and validation data criteria, using Likert scale. (Sugiyono, 2018) states that the Likert scale can be used as a benchmark for assessing a person's attitude, opinion, and perception on a topic.

Table 1. Assessment criteria

Assessment scale	Percentage (%)	Eligibility rate
5	80-100	Excellent
4	60-79	Good
3	40-59	Sufficient
2	20-39	Bad
1	0-19	Poor

$$P = \frac{\Sigma x}{\Sigma xi} \text{ x } 100\%$$

Information:

P = Percentage

$\sum x$ = Total number of scores obtained

$\sum x_i$ = Maximum number of scores

100% = Maximum Percentage

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In analyzing, data analysis techniques are used, namely: 1) Validity Test; according to Kriyanto (2020), "the validity test aims to provide a statement of the extent of measurements and instruments to be measured. The valid meaning here is being able to show to what extent a measuring instrument is able to measure what it wants to measure (able to be a research object tool). 2) Test N-Gain Score; According to (Sugiyono, 2018), the N-Gain Test was conducted to determine the improvement of cognitive learning outcomes of students after being given treatment. The increase comes from the processing of students' pre-test and post-test scores. The value is then analysed for increased results using N-gain analysis with a formula as follows:

$$g = \frac{sr-si}{smax-si}$$

Information:

g = Score gain
Sr = Final score (post-test)
Si = Initial score (pre-test)
S_{max} = Possible maximum score

Table 2. N-gain Interpretation Criteria

Gain score interval	Criteria
g > 0,7	High
0,3≤ g ≤ 0,7	Moderate
g < 0,3	Low

Table 3. Categories Interpretation of N-Gain Score Effectiveness

Percentage (%)	Interpretation
<40	Ineffective
40-55	Less Effective
56-75	Quite Effective
>76	Effective

RESULTS AND DISCUSSION

The result of this study was divided into four expertise fields (1) Instrument Validity (2) The performance of AR-based learning media on Electromagnetic induction (3) performance of the student learning outcomes

Instrument Validity

Validity is used to assess the viability of educational media with augmented reality electromagnetic induction content. Two qualified validators in the area of physics education validated the media. The feasibility of the instrument is assessed based on several aspects including: 1) Learning implementation plan 2) AR Media Application 3) Pre test and post test 4) Student Response Questionnaire.

Table 4. Validation of Research Instruments by Expert Validator

Aspect	Expert validator 1	Expert Validator 2	Total Score	Average Percentage Value (%)
Learning Implementation Plan	90	96	186	93 (Excellent)
AR Media Application	96	95	191	96 (Excellent)
Pre test dan post test	96	98	194	97 (Excellent)
Student Response Questionnaire	95	95	190	95 (Excellent)

According to Table 4 validation results, the average percentage value of a learning plan's validation is 93%, while that of an AR media application's validation is 96%, that of pre-test and post-test's validation is 97%, and that of a student response survey's validation is 95% on average.

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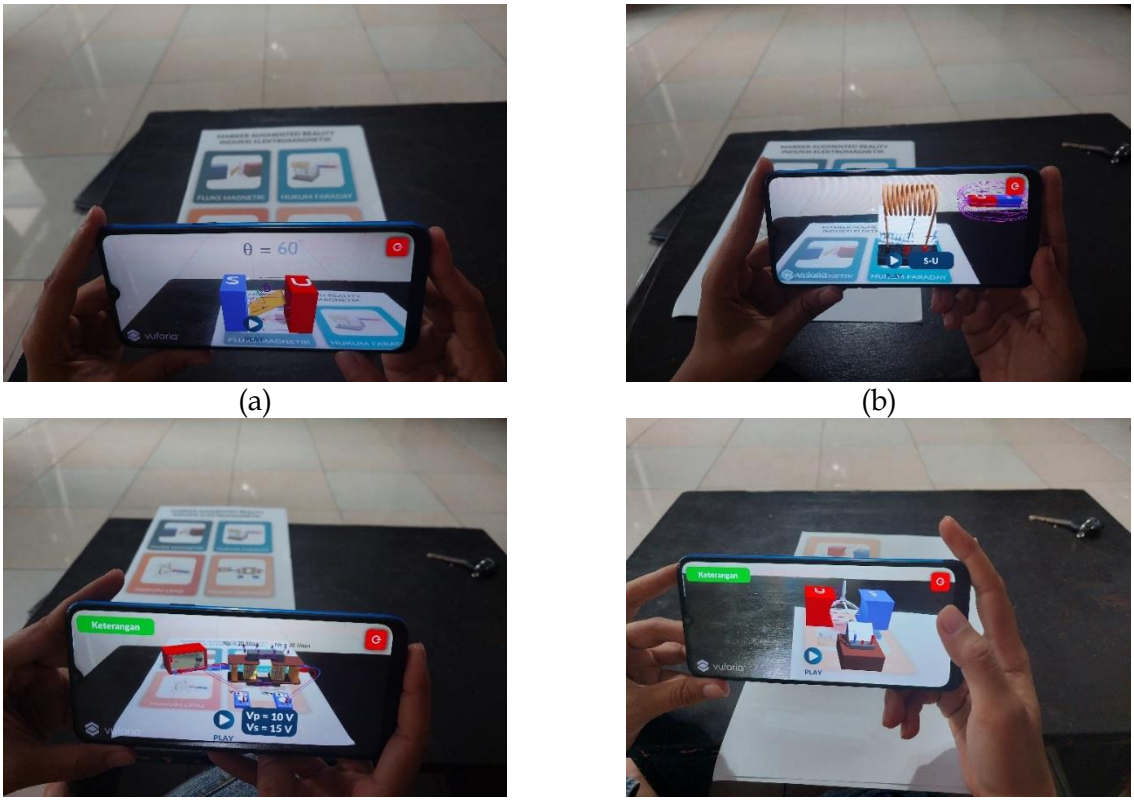
As a result, it can be said that all learning media research tools based on electromagnetic induction and augmented reality are excellent choices for classroom application and have undergone revisions per the recommendations of professional validators.

The performance of AR-based learning media on Electromagnetic induction

There are benefits to using the author's built augmented reality application to depict a magnetic flux substance.



(a) (b)

(c) (d)

Figure 8. The performance of AR-based learning media on Electromagnetic induction

In Figure 8. (a) The quantity of magnetic force lines that pass through a specific field area is known as magnetic flux. Using the augmented reality application developed by the author has advantages in illustrating a magnetic flux material. Illustration of the number of lines of magnetic force that enter an area will adjust the angle of inclination of an area. The angle of inclination of a region will change depending on how many magnetic force lines enter it. (b) Michael Faraday, a physicist, used coils, magnetic rods, and galvanometers to examine the magnetic field that may generate an electric current. The galvanometer needle veers to the right when the bar magnet is moved toward the coil. This happens because as the magnetic flux and induced emf grow due to an increase in the lines of magnetic force, respectively. The galvanometer needle does not move while the bar magnet is stationary or at rest. shows that no induced emf has taken place. The galvanometer needle veers to the left when the bar magnet is pushed away from the coil. This is because as the magnetic flux declines, the lines of magnetic force do as well. The negative sign in the equations of Faraday's law is explained by Lenz's law. With a negative sign, a magnetic field will be produced whose direction opposes the shift in the lines of magnetic force caused by the induced current flowing in the conductor wire. (c) The transformer makes use of a wire coil that, when subjected to an alternating current, produces electromagnetic induction. Thus, a magnetic field is created when an electric current flows through a coil of wire. (d) The electromagnetic induction theory serves as the foundation for how the transformer operates. The transformer makes use of a wire coil that, when subjected to an alternating current, produces electromagnetic induction. Thus, a magnetic field is created when an electric current flows through a coil of wire.

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The Performance of the student learning outcomes

In the Table 4. The initial test has an average of 61.45 from 31 student data with a standard deviation of 6.217. While the final test obtained an average of 90.81 from 31 student data with a standard deviation of 8.573. This shows that the post test on the data is higher than the pre test. Based on table 5. The correlation coefficient is 0.134 with a significance value of 0.474. Because the significance value of 0.474 is less than the probability value of 0.05, the pre-test variables have no relationship with the post-test variables.

Table 4. Paired samples statistic

Paired Samples Statistics				
	Mean	N	Std. Deviation	Std. Error Mean
Pre Test	61.45	31	6.217	1.117
Post Test	90.81	31	8.573	1.540

Table 5. Paired samples correlation

Paired Samples Correlations			
	N	Correlation	Sig.
Pre test - post test	31	.134	.474

Table 6. Paired samples test

Paired Samples Test								
	Paired Differences							
			Std. Error Mean	95% Confidence Interval of the Difference				
	Mean	Std. Deviation		Lower	Upper	t	df	Sig. (2-tailed)
Pre test - post test	-29.355	9.895	1.777	-32.984	-25.725	-16.518	30	.000

The calculation results of the paired samples test show a significance value (2-tailed) of 0.000 using a significance level of 5%. Seeing the significance value (2-tailed) is less than 0.05, there is a significant effect on the treatment given to the research subjects. Thus it can be concluded that learning using augmented reality-based media has a significant effect on students' cognitive learning outcomes.

The N-Gain Score Test

Based on the students' pretest and posttest scores which were analyzed using N-gain analysis, the following results were obtained:

Table 7. Descriptive statistics

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	31	.25	1.00	.7617	.22549
Ngain_Persen	31	25.00	100.00	76.1662	22.54859
Valid N (listwise)	31				

The value of N gain score, the mean value obtained is 0.7617, the value is greater than 0.7, so the category obtained is high which means high effectiveness. Then the value of n gain percent, the mean value obtained is 76.1662 meaning that the value is greater than 76%, so the interpretation is in the effective category. It can be interpreted that the use of AR-based learning media on electromagnetic induction subject matter has been effective.

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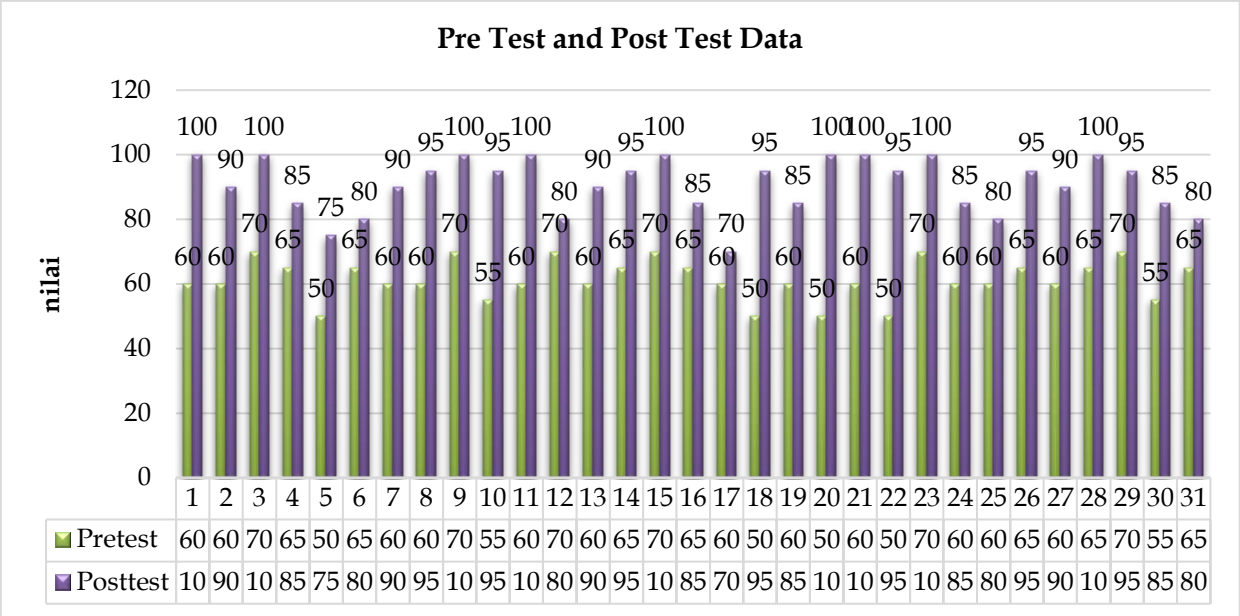

Figure 3. Pretest and Post Test Results Diagram

Based on Figure 3, data can be generated as many as 25 students get pretest scores below the standard value, while 6 other students have exceeded the specified standard. Students who don't meet the reference requirement because they don't yet have an abstract comprehension of how the electromagnetic induction process is illustrated. Students continue to struggle with the direction of magnetic motion, only understand general ideas from the material they have been given, and have not yet developed a complete understanding of electromagnetic induction.

Because Augmented Reality-based learning media can help students better understand and see the details of their physical concepts so that they can enter long-term memory, some students also experienced an increase in learning achievement in the high category. This is also supported by other studies that show an increase in learning outcomes. students, especially in the cognitive domain after using AR media (Qorimah & Sutama 2022). The results of other studies revealed that after participating in learning using pocket books based on augmented reality, the results of student learning increased (Suprapto et al., 2021). Based on the results of AR-based learning media research conducted by the author and corroborated by previous research, that AR-based learning media has proven to be effective to apply and can assist students in improving students' cognitive learning outcomes.

Tabel 8. Percentage of student responses

The average percentage of response result (%)	kategori
87 %	Sangat baik

The results were reactions to augmented reality-based learning media with 31 students as respondents, based on the questionnaire that the respondents filled out. has a very good acquisition rate of 87% on average. The augmented reality-based learning media that has been created is rated as being suitable for use as a teaching tool based on the findings of the validation. so that the general public and diverse schools can use this educational technology.

CONCLUSION

The development of learning media based on augmented reality electromagnetic induction subject matter in the valid category is very feasible to use. Students' cognitive learning outcomes increased as a result of trials conducted based on the results of a mean N gain of 0.76. The results of the independent t-test showed that there was a significant effect on both variables with a

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significance of 2 tails of 0.000. The results of student responses indicate that learning media is very feasible to use with an average percentage value of 87%. Thus, learning media based on augmented reality is recommended for use in physics concepts that require high abstract thinking and understanding. However, this study has limitations on the material applied. The hope is that in future research it can integrate more physics material so that the material presented is more interesting to students.

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