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Exploring the Impact of Augmented Reality on Meaningful Learning in Islamic Religious Education: A Quantitative Analysis

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ABSTRACT

This study aims to investigate the effect of Augmented Reality (AR) on the meaningfulness of learning Islamic religious education. AR tested in this study include Smart Glasses AR (X1), Mobile Augmented Reality Application (X2), and AR in Books (X1). While the learning meaningfulness variable is divided into three indicators by referring to Clark and Daryanes' theory including problem solving (Y1), critical thinking skills (Y2), and learning motivation (Y3). This quantitative research uses multiple linear regression analysis model. Data was collected through a survey of 99 research respondents. The results show that AR has the most significant impact in increasing learning motivation, as its additional elements create an engaging and interactive learning experience. AR's influence on critical thinking ability ranked second, as the technology encourages the development of analytical and evaluative skills. This is due to AR's focus on improving concept understanding and learner engagement in the learning process. In contrast, the least impact of AR was seen on problem-solving ability, where this technology is more likely to increase motivation and concept understanding rather than providing direct solutions to problems. These findings contribute to improving the understanding of how AR can shape more meaningful learning experiences in the context of Islamic religious education.

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ABSTRACT

Penelitian ini bertujuan untuk mengukur pengaruh Augmented Reality (AR) terhadap pembelajaran bermakna Pendidikan Agama Islam. AR yang diuji dalam penelitian ini meliputi Smart Glasses AR (X1), Aplikasi Mobile Augmented Reality (X2), dan AR dalam Buku (X1). Variabel kebermaknaan pembelajaran dibagi menjadi tiga indikator dengan merujuk pada teori Clark dan Daryanes, yaitu pemecahan masalah (Y1), keterampilan berpikir kritis (Y2), dan motivasi belajar (Y3). Penelitian kuantitatif ini menggunakan model analisis regresi linier berganda. Data dikumpulkan melalui survei terhadap 99 responden penelitian. Hasil penelitian menunjukkan bahwa AR memiliki dampak paling signifikan dalam meningkatkan motivasi belajar, karena elemen tambahannya menciptakan pengalaman belajar yang menarik dan interaktif. Pengaruh AR terhadap kemampuan berpikir kritis berada di peringkat kedua, karena teknologi ini mendorong pengembangan keterampilan analitis dan evaluatif. Hal ini disebabkan oleh fokus AR dalam meningkatkan pemahaman konsep dan keterlibatan peserta didik dalam proses pembelajaran. Sebaliknya, dampak AR yang paling sedikit terlihat pada kemampuan pemecahan masalah, di mana teknologi ini lebih cenderung meningkatkan motivasi dan pemahaman konsep daripada memberikan solusi langsung terhadap masalah. Temuan ini berkontribusi pada peningkatan pemahaman tentang bagaimana AR dapat membentuk pengalaman belajar yang lebih bermakna dalam konteks pendidikan agama Islam.

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Introduction

The Meaningful learning plays an important role in character development and student understanding of the material. Its application can minimize the retention of information taught to students (Agra et al., 2019). When students cannot relate learning to practical experience or real meaning, they tend to lose motivation and interest in the learning (Mystakidis, 2021). As a result, students only memorize information to face exams without really understanding the concepts taught by the teacher (Farel Onowugbeda et al., 2022). This situation is not fully considered by teachers, because so far learning has focused more on achieving understanding of the material, not on the meaningfulness of learning (Da Silva, 2020). this happens because of limited resources for teachers to implement meaningful learning, including aspects of limited learning media (Hsbollah, & Hassan, 2022). This is important to ensure that students can relate the material to their daily lives, so that learning can trigger interest and deep understanding (Pilegard & Fiorella, 2021).

Among the educational technologies that support meaningful learning is Augmented Reality (AR). The nature of AR that allows students to interact with subject matter in a more realistic and engaging context can make learning more meaningful and relevant to students (Garzón James, 2021). This can improve students' understanding and engagement in the learning process (Avila Garzon, 2021). However, it should be noted that students' resistance to AR as a new technology can be an obstacle that needs to be overcome in its implementation. Therefore, it is necessary to conduct a careful evaluation to assess the extent to which the use of AR impacts the achievement of meaningful learning (Kljun, Geroimenko, & Čopič Pucihar, 2020). This assessment plays an important role in illustrating how students respond to this technology and the extent of AR's contribution in achieving deeper educational goals.

AR technology has revealed great potential and significant impact in educational contexts (John Quintero, 2019). This impact has been observed in various disciplines, such as probability and medical education (Wüller & Behrens, 2019), maintenance (Mourtzis, Siatras & Angelopoulos, 2020), the world of fashion and modern fashion trends (Abou El-Seoud & Taj Eddin, 2019), social sciences that study people's behavior (Masalimova, 2023), as well as various other fields of knowledge. Although many studies have been conducted in the use of AR in education, there is still a lack of understanding regarding the application of AR in religious learning (Llerena-Izquierdo & Cedeño Gonzabay, 2019), which looks at the extent to which AR can be applied in the context of Islamic education for high school students (Tanjung & Harfiani, 2019), this is important because they are at an age with unstable psychology that requires media according to their age development (Copic Pucihar, 2020).

The use of AR technology in social science learning has been shown to improve academic achievement (LópezBelmonte, 2019); however, measurements comparing the effects of the three most popular AR applications (Smart Glasses AR, Augmented Reality Mobile App, and AR in Books), as well as the role of AR applications in supporting the meaningfulness of Islamic religious learning still need to be explored. This is important to ensure that the use of AR in religious learning can help provide clearer insights into how much influence it has in achieving meaningful learning (Cabero Almenara et al., 2019). Therefore, to address the knowledge gap in the literature, we have developed an interactive AR application with the aim of understanding the most suitable AR application for Islamic religious learning, while identifying factors that influence its success among high school students in Indonesia.

Augmented Reality and in the Development of Modern Islamic Pedagogy

Augmented Reality (AR) is a technology that combines digital elements with the real world through electronic devices, such as smartphones, tablets, or smart glasses (Dwivedi et al., 2022). This technology allows users to see virtual objects added to their physical environment, creating an immersive interactive experience (Chen et al., 2023). In the context of Islamic education, AR can be a very useful tool for conveying religious teachings in a more interesting and understandable way. For example, abstract concepts such as the pillars of faith, the life history of the Prophet Muhammad SAW, or the procedures for the Hajj pilgrimage can be visualized interactively through AR. Thus, students not only read the text but also see, hear, and even interact with the subject matter. This can improve students' understanding, interest in learning, and memory of religious lessons (Khairuldin et al., 2019).

Smart Glasses AR is one type of AR that uses smart glasses to display digital information directly in front of the user's eyes (Kim, Park & Lee, 2019). In Islamic education, smart glasses can be used to simulate prayer or ablution procedures in real time, where students can see the visual steps that appear in front of them while practicing . Furthermore, the Mobile Augmented Reality Application utilizes a smartphone or tablet to display AR content through the device's camera. For example, this application can be used to explain the meaning of the verses of the Qur'an with 3D animations when students point the camera at certain texts (Asril et al., 2023). Finally, AR in Books is a technology that integrates digital elements into printed books through markers (Sig et al., 2020). When students scan the pages of the book with their devices, they can see relevant videos, audio, or animations. For example, a book about Islamic history can show a 3D reconstruction of the Kaaba or important events in Islam (Panchenko, Vakaliuk & Vlasenko, 2020).

These three types of AR complement each other in the development of modern Islamic pedagogy. Smart Glasses AR provides a fully immersive learning experience, suitable for worship practices that require physical movement. Mobile AR applications are more flexible because they can be accessed through devices that many students already own, making it easier to distribute learning materials. Meanwhile, AR in Books maintains the traditional value of religious literature while adding digital elements that make it more attractive to the digital generation. The three together create a holistic learning ecosystem, where students can learn through various methods according to their preferences and needs. With this integration, Islamic Religious Education becomes not only more interactive but also more inclusive, ensuring that all students can better understand and practice Islamic teachings (Mustafa et al., 2025).

Meaningful Learning in Islamic Religious Education

Meaningful learning in Islamic religious education refers to a learning process that is not only memorizing but also understanding, reflecting on, and practicing the values of Islamic teachings in everyday life. In this context, meaningful learning includes the transformation of religious knowledge into real actions that reflect devotion to Allah SWT (Zabidi rt al., 2023). One of the main principles in meaningful learning is the use of methods that encourage students to think critically, reflectively, and creatively. For example, teachers can use a guided discussion approach, case studies, or problem solving that is relevant to students' social and spiritual lives (Ghazali, 2020). In addition, meaningful learning also emphasizes the importance of the relationship between theory and practice. Students are invited to not only understand concepts such as prayer, fasting, zakat, and hajj textually, but also understand the philosophical meaning behind these worships. Thus, meaningful learning in Islamic religious education aims to form individuals who have a deep understanding of Islamic teachings and are able to integrate them into their lives (Shuell, 1990).

One theory that is relevant to meaningful learning in Islamic religious education is the constructivist learning theory. This theory emphasizes that knowledge is constructed by individuals through interaction with the environment and personal experiences (Zajda & Zajda, 2021). In the context of Islamic religious education, constructivism can be applied by encouraging students to connect religious lessons with the realities of their lives (Toker, 2021). For example, when studying the concept of justice in Islam, students can be asked to analyze social issues such as poverty or legal injustice, then formulate solutions based on Islamic principles. In addition, Albert Bandura's social learning theory is also relevant because it emphasizes the importance of observation and imitation in learning. In Islamic religious education, teachers can be models of good Islamic behavior, so that students can learn through real examples (Ismail & Rahman, 2012). By applying these theories, Islamic religious learning can be more dynamic and relevant to students' lives.

Another theory that supports meaningful learning is the humanistic theory put forward by Carl Rogers. This theory emphasizes the importance of emotional and psychological aspects in the learning process (Rogers, Lyon, & Tausch, 2013). In Islamic religious education, a humanistic approach can be applied by creating an inclusive, compassionate, and respectful learning environment for each individual. Teachers need to build warm relationships with students so that they feel safe and motivated to learn. In addition, Howard Gardner's multiple intelligences theory can also be used to adjust learning methods to the diverse needs of students (Ghaznavi, Haddad & Tajadini, 2021). For example, students with interpersonal intelligence can be asked to work in groups to solve Islamic ethical problems, while students with kinesthetic intelligence can be invited to practice the correct movements of prayer. By combining these theories, Islamic religious education can be an effective means of forming individuals who are faithful, knowledgeable, and do good deeds (Kolb, 2023).

Methods

Research Design

This research is quantitative in nature using multiple linear regression analysis methods. This analysis involves several stages to identify and understand the relationship between independent variables and dependent variables in a statistical model. These stages include data collection, variable selection, parameter estimation, assumption verification, and result interpretation (Oukawa, Krecl & Targino 2022). First, data collection is done by collecting information related to the dependent and independent

variables from the observed sample. Then, the selection of variables is done carefully to ensure that the variables included in the model have theoretical relevance and significance. Once the variables are selected, the parameter estimation stage is performed to calculate the regression coefficients through methods such as the least squares method (Neethu, 2022). Assumption verification is the next crucial step, which involves checking the basic assumptions of regression, such as homoscedasticity, normality of residuals, and independence of residuals (Mamatha et al., 2023). Finally, interpretation of the regression results is done to draw conclusions about the relationship of the variables and make predictions based on the model that has been built.

Participants

The population of focus in this study were students who were at the second grade level in three Senior High School in Central Java, namely: 1) SMA Negeri 1 Bawang, 2) SMK Negeri Kandeman, 3) SMA Negeri 1 Bandar. These three schools are located in Central Java, Indonesia. The institutions we chose are known as educational institutions that organize Islamic religious education subjects as a compulsory part for students who are Muslims in Indonesia. Therefore, the samples taken were designed to reflect the characteristics of the students as a whole (Rahman Musthofa, 2022). The number of respondents in this study included students from various majors totaling 99 people. The process of selecting research subjects was carried out using proportional sampling method, where the sample was taken proportionally to reflect the overall distribution (David Mertens, 2023).

Data Collection

This study used a survey as its data collection method. This technique was carried out systematically. Students were given a series of questions representing numerical indicators of augmented reality and meaningful learning variables on a Likert scale. It consists of fifty-one questions intended to determine the difference in the effect of Smart Glass AR, Mobile Augmented Reality Application, and AR in books on the meaningfulness of learning.

Data Analysis

This study employed two data analysis methods: descriptive statistical analysis and inferential statistical analysis. Descriptive statistical analysis was used to describe the collected data, focusing on augmented reality and meaningful learning. Meanwhile, inferential statistical analysis was applied for hypothesis testing. The hypothesis testing was conducted using multiple linear regression analysis with a significance level (α) of 0.050 (Salleh, 2023), and the process was carried out using Statistical Product and Service Solutions (SPSS) software. Before carrying out multiple linear regression analysis, swimmer tests were carried out including normality tests using the Kolmogorov-Smirnov method, exact tests using Glejser, and independent tests using Durbin-Watson. Decisions regarding hypotheses are based on the criterion that H0 is rejected if the p value < α (0.05), whereas H0 is accepted if the p value is > α (0.05) (Jafar et al., 2023).

Validity and Reliability

The process of identifying meaningful learning variables through a survey method that uses a Likert scale as a measurement tool. Data collection requires instruments that have passed a feasibility test, consist of a reliability test and a Validity test, to produce quality test questions (Vance et al., 2023). Validity is considered a crucial element in any test and is defined as the accuracy and accuracy of the instrument in carrying out its function. If the instrument is proven to be valid, it means that the instrument can be used for measurement (Fischer, Boone, & Neumann, 2023). Validity testing is conducted to

evaluate the extent to which the instrument is appropriate for identifying student learning patterns (Sürücü & Maslakci, 2020). In this study, reliability testing was conducted using the Cronbach's Alpha formula with the assistance of SPSS software. The reliability test results for variables X1, X3, Y1, Y2, and Y3 are documented as follows.

Table 1. Validity instrument.

Statement	p-Values (X1)	p-Values (X2)	p-Values (X3)	p-Values (Y1)	p-Values (Y2)	p-Values (Y3)
1	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000
8	-	-	-	0.000	0.000	0.000
9	-	-	-	0.000	0.000	0.000
10	-	-	-	0.016	0.000	0.000

The table above shows the level of correlation significance for each statement on variables (X1), (X2), (X3), (Y1), (Y2), and (Y3) against the total statement value. Of all the attributes contained in each variable, it appears that all attributes have a p value lower than alpha (0.05), resulting in a decision to reject H0. This indicates that all attribute items are considered valid.

The next step includes a reliability check, an evaluation process that aims to obtain reliable measurement results for a number of measurements on similar groups of subjects, and produce consistent results (Rose & Johnson, 2020). In this research, reliability testing was carried out using the Cronbach's Alpha formula with the support of SPSS software. The following are the results of the reliability test for variables X1, X2, X3, Y1, Y2, and Y3 which are documented in Table 2.

Table 2. Reliability Test X1, X2, X3, Y1, Y2, Y3.

Variable	Cronbach's Alpha	Variable	Cronbach's Alpha
X1	0.722	Y1	0.537
X2	0.716	Y2	0.679
X3	0.780	Y3	0.812

The table above presents the results of the Cronbach's Alpha calculations for various variables, comparing two groups: X1, X2, and X3 in one group, and Y1, Y2, and Y3 in the other. Cronbach's Alpha serves as a measure of reliability, assessing the internal consistency of items within a measurement instrument. In this case, since the Cronbach's Alpha value is equal to or greater than 0.700, the decision is to reject H0. This indicates that the reliability measurements for variables X1, X2, X3, Y1, Y2, and Y3 are relatively consistent.

Results and Discussion

Result

Descriptive Statistical Analysis

This study aims to investigate the effect of Augmented Reality (AR) on meaningful learning of Islamic religious education for high school students in Indonesia. Three

popular AR tools, namely Smart Glasses AR (X1), Mobile Augmented Reality Application (X2), and AR in Books (X1), are the focus of comparison in this study. The learning meaningfulness variable is divided into components that determine learning success, including problem solving (Y1), critical thinking skills (Y2), and learning motivation (Y3). Before carrying out a multiple linear regression analysis test, it is important to carry out descriptive analysis first to get a general understanding of the data used in the research. The following is a summary of the gender of the respondents in this study, which can be seen in Figure 1

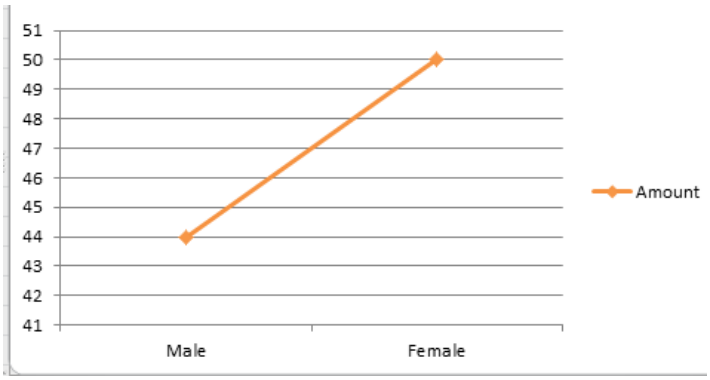

Figure 1. Bar chart of respondents' genders.

Figure 1 provides an explanation that the majority of respondents are female (n = 99 respondents consisting of 50 female respondents and 44 male respondents). The following is a description of the average student test scores for the last three meetings in the Islamic education subject as a subject that explicitly aims to make students able to understand the teachings of Islam. Figure 4.2 shows the grades of the last three Islamic education subjects.

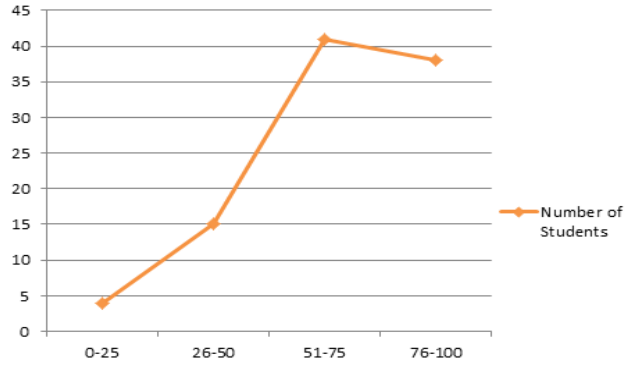

Figure 2. The grades of the last three Islamic education subjects

See table 3 to find out the highest, lowest, and average scores of the last three daily tests in Islamic education subjects.

Table 3. Statistics of student grades for the last three meetings

Variables	Maximum	Minimum	Mean
GPA	100	25	73,4

In the last three meetings, the evaluation results of the Islamic Religious Education (PAI) subject scores showed significant variations. Table 3 illustrates the statistics of students' scores, with a mean score of 73.4. While some students achieved the highest score of 100, others achieved the lowest score of 25. It should be noted that the achievement of such scores can be an indicator of the success of the teaching method and

the need for improvement in the Islamic Education learning approach to improve overall learning outcomes.

Next, the figure below provides an explanation of the distribution of the provincial origin of the respondents.

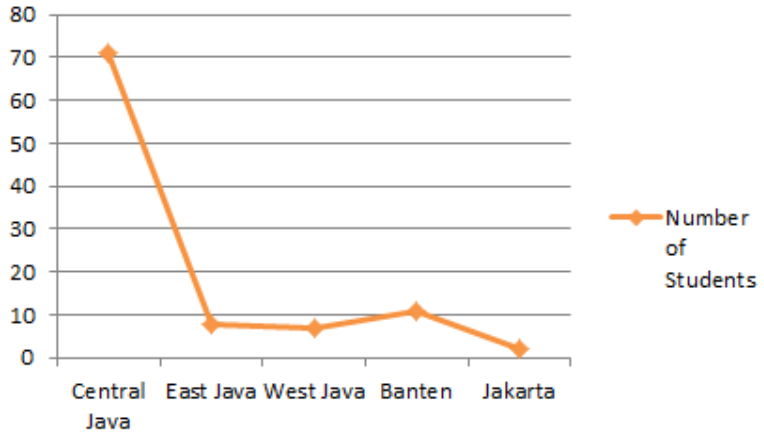

Figure 3. Distribution of provincial origin of the respondents

The table shows the distribution of students based on their province of origin. Overall, there were 71 students from Central Java, 8 from East Java, 7 from West Java, 11 from Banten, and 2 from Jakarta. This data illustrates that the majority of respondents come from Central Java, while other provinces have a lower contribution in the number of students who become respondents. Further analysis of this difference in distribution may provide additional insight into geographical variations in respondent participation in research or surveys conducted. The next step is to conduct the Canonical Correlation Assumption Test (CCAT) to evaluate the extent to which the assumptions underlying canonical correlation analysis have been met. This is important to ensure that the linear relationship between two sets of multivariate measured variables truly reflects a significant canonical correlation.

Canonical Correlation Assumption Test

Multivariate Normality Test

Table 4. Multivariate normality test variable X1 X2 X3 with Y1

	Smart Glasses AR	AR Mobile App	AR in Book	Problem Solving
Chi-Square(a,b,c)	28,576	49,444	53,323	37,828
Df	9	7	7	25
Asymp. Sig.	,001	,000	,000	,048

The table above presents the results of the chi-square test for four different conditions related to the use of Smart Glasses AR, Mobile Augmented Reality Application, AR in Books, and students' ability in problem solving. The chi-square ($\chi 2$) values for each condition are as follows: 28.576 for Smart Glasses AR, 49.444 for Augmented Reality Mobile App, 53.323 for AR in Books, and 37.828 for Problem Solving. Degree of freedom (df) used in testing is 9 for Smart Glasses AR, 7 for Augmented Reality Mobile App and AR in Books, and 25 for Problem Solving. The value of Asymp. Sig. (Asymptotic Significance) values listed are ,001 for Smart Glasses AR, ,000 for Augmented Reality Mobile App and AR in Books, and ,048 for Problem Solving, respectively. These values indicate the

statistical significance of the chi-square test results, and lower values indicate a higher level of significance. The conclusion is that there is a significant relationship between Smart Glasses AR, Augmented Reality Mobile App, AR in Books and Problem Solving due to the Asymp. Sig. values are 0.001, 0.000, 0.000 and 0.048 <0.05.

Linearity Test

Table 5. Linearity test of variable X1 with Y1

			Sum of Squares	df	Mean Square	F	Sig.
Problem Solving * Smart Glasses AR	Between Groups	(Combined)	451,046	9	50,116	1,228	,289
		Linearity	40,982	1	40,982	1,004	,319
		Deviation from Linearity	410,064	8	51,258	1,256	,277
	Within Groups		3633,459	89	40,825		
	Total		4084,505	98			

In accordance with the test carried out, it is stated that variable X1 with variable Y1 has test results of 0.1004 and 0.1256. This test value is greater than 0.05. Then the linearity assumption is strong enough because F-Linearity is in the significant range.
Table 6. Linearity test of Variable X1 with Y2

Table 6. Linearity test of Variable X1 with Y2

			Sum of Squares	df	Mean Square	F	Sig.
Critical Thinking * Smart Glasses AR	Between Groups	(Combined)	734,705	9	81,634	1,793	,081
		Linearity	135,956	1	135,956	2,986	,087
		Deviation from Linearity	598,749	8	74,844	1,644	,124
	Within Groups		4052,466	89	45,533		
	Total		4787,172	98			

The test results above provide one explanation that the X1 variable with the Y2 variable has a test result of 0.2986 and 0.1644. This test value is greater than 0.05. So the linearity assumption is quite strong because F-Linearity is in a significant range.

Table 7. Linearity test of Variable X1 with Y3

			Sum of Squares	df	Mean Square	F	Sig.
Learning Motivasion * Smart Glasses AR	Between Groups	(Combined)	927,660	9	103,073	1,161	,330
		Linearity	255,585	1	255,585	2,878	,093
			672,075	8	84,009	,946	,483

		Deviation from Linearity				
	Within Groups		7903,754	89	88,806	
	Total		8831,414	98		

In accordance with the test carried out, it is stated that variable X1 with variable Y3 has test results of 0.2878 and 0.946. This test value is greater than 0.05. Then the linearity assumption is strong enough because F-Linearity is in the significant range.

Table 8. Linearity test of Variable X2 with Y1

			Sum of Squares	df	Mean Square	F	Sig.
Critical Thinking* AR Mobile App	Between Groups	(Combined)	477,167	7	68,167	1,439	,199
		Linearity	2,000	1	2,000	,042	,838
		Deviation from Linearity	475,167	6	79,194	1,672	,137
	Within Groups		4310,005	91	47,363		
	Total		4787,172	98			

In accordance with the test carried out, it is stated that the variable X2 with the variable Y2 has test results of 0.2000 and 0.79194. This test value is greater than 0.05. Then the linearity assumption is strong enough because the F-Linearity is in the significant range.

Table 9. Linearity test of Variable X2 with Y3

			Sum of Squares	df	Mean Square	F	Sig.
Learning Motivasion * AR Mobile App	Between Groups	(Combined)	790,350	7	112,907	1,278	,270
		Linearity	46,905	1	46,905	,531	,468
		Deviation from Linearity	743,445	6	123,908	1,402	,222
	Within Groups		8041,064	91	88,363		
	Total		8831,414	98			

In accordance with the test carried out, it is stated that the variable X2 with variable Y3 has test results of 0.531 and 0.1402. This test value is greater than 0.05. Then the linearity assumption is strong enough because the F-Linearity is in the significant range.

Table 10. Linearity test of Variable X3 with Y1

		Sum of Squares	df	Mean Square	F	Sig.
	(Combined)	223,113	7	31,873	,751	,629

Problem Solving * AR in Book	Between Groups	Linearity	89,707	1	89,707	2,114	,149
		Deviation from Linearity	133,406	6	22,234	,524	,789
	Within Groups		3861,392	91	42,433		
	Total		4084,505	98			

In accordance with the test carried out, it is stated that the X3 variable with the Y2 variable has test results of 0.536 and 0.1433. This test value is greater than 0.05. Then the linearity assumption is strong enough because F-Linearity is in the significant range of.

Table 11. Linearity test of Variable X3 with Y3

			Sum of Squares	df	Mean Square	F	Sig.
Learning Motivation * AR in Book	Between Groups	(Combined)	489,479	7	69,926	,763	,620
		Linearity	10,805	1	10,805	,118	,732
		Deviation from Linearity	478,675	6	79,779	,870	,520
	Within Groups		8341,935	91	91,670		
	Total		8831,414	98			

In accordance with the test carried out, it is stated that the X3 variable with the Y3 variable has test results of 0.118 and 0.870. This test value is greater than 0.05. Then the linearity assumption is strong enough because F-Linearity is in the significant range of.

Multicollinearity Test

Multicollinearity testing is a crucial step in regression analysis aimed at evaluating the degree of interdependence among independent variables. Multicollinearity occurs when two or more independent variables in a regression model are highly correlated, making it challenging to distinguish the unique influence of each variable on the dependent variable. If the coefficient value is greater than or equal to 0.700, the decision is made to reject H0. This indicates that the reliability measurements for variables X1, X2, X3, Y1, Y2, and Y3 are relatively consistent. The importance of this test lies in its ability to detect this problem, as multicollinearity can lead to inaccurate and unreliable results in regression analysis.

Table 12. Regression Relationship X1 X2 X3

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta	Tolerance	VIF	B	Std. Error
1	(Constant)	139,625	13,337		10,469	,000		
	Smart Glasses AR	-,204	,270	-,078	-,758	,451	,960	1,042

	AR Mobile Apps	-,060	,441	-,014	-,135	,893	,940	1,064
	AR in Books	-,567	,456	-,131	-1,243	,217	,915	1,093

Based on the Coeffientcs table, it is known that the VIF (Variance Inflation Factor) value for variable X1 is 0.451, X2 is 0.893, X3 is 0.217 and variable Y1 is 0.000. Each independent variable has a VIF value of less than 10, so it is accepted. So it can be concluded that there is no multicollinearity problem among the independent variables.

Homoskedasticity Test

The next step is to conduct a test to assess the homogeneity of the variance of the data within a sample. Homoscedasticity refers to the condition where the variance of a random variable in a population or sample remains constant. The importance of the homoskedasticity test is especially apparent in the context of regression analysis and analysis of variance (ANOVA). In both of these analyses, the assumption of homoscedasticity must be met for the statistical results to be reliable and valid.

Tabel 13. Homoscedasticity X1 X2 X3 with Y1

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta	Tolerance	VIF	B	Std. Error
1	(Constant)	139,625	13,337		10,469	,000		
	Smart Glasses AR	-,204	,270	-,078	-,758	,451	,960	1,042
	AR Mobile Apps	-,060	,441	-,014	-,135	,893	,940	1,064
	AR in Books	-,567	,456	-,131	-1,243	,217	,915	1,093

Based on the Coefficients table, it is known that the variables X1, X2, X3 have values of 0.451, 0.893 and 0.217. Then all variables fulfill the assumption of homoscedasticity because the test value exceeds 0.05.

Tabel 14. Homoscedasticity X1 X2 X3 with Y2

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta	Tolerance	VIF	B	Std. Error
1	(Constant)	135,341	14,416		9,388	,000		
	Smart Glasses AR	-,448	,291	-,158	-1,537	,128	,960	1,042
	AR Mobile Apps	,103	,477	,023	,217	,829	,940	1,064
	AR in Books	-,237	,493	-,051	-,481	,632	,915	1,093

Based on the Coefficients table, it is known that the variables X1, X2, X3 have values of 0.128, 0.829 and 0.632. Then all variables fulfill the assumption of homoscedasticity because the test value exceeds 0.05.

Tabel 15. Homoscedasticity X1 X2 X3 with Y3

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	Collinearity Statistics

		B	Std. Error	Beta	Tolerance	VIF	B	Std. Error
1	(Constant)	135,552	19,453		6,968	,000		
	Smart Glasses AR	-,738	,393	-,192	-1,876	,064	,960	1,042
	AR Mobile Apps	-,651	,644	-,105	-1,011	,315	,940	1,064
	AR in Books	,581	,665	,092	,874	,384	,915	1,093

Based on the Coefficients table, it is known that the variables X1, X2, X3 have values of 0.064, 0.315 and 0.384. Then all variables fulfill the assumption of homoscedasticity because the test value exceeds 0.05.

Canonical Correlation Test

At the next stage, it is important to conduct a canonical test in order to measure the relationship between two sets of variables consisting of two or more groups. The importance of this test lies in its ability to identify complex relationships between two sets of variables, focusing on linear and non-linear correlations that may occur simultaneously. The Canonical Correlation Test helps researchers or data analysts to understand the extent to which two groups of variables interact, and in what contexts the relationship is strongest.

Tabel 16. Eigenvalues and Canonical Correlations

Root No.	Eigenvalue	Pct.	Cum. Pct.	Canon Cor.	Sq. Cor
1	0.048	51.646	51.646	0.215	0.046
2	0.040	42.551	94.198	0.196	0.038
3	0.005	5.802	100.000	0.073	0.005

Tabel 17. Dimension Reduction Analysis

Roots	Wilks L.	F	Hypoth. DF	Error DF	Sig. of F
1 TO 3	0.91239	0.96617	9.00	226.49	0.0469
2 TO 3	0.95650	1.05688	4.00	188.00	0.0379
3 TO 3	0.99460	0.51598	1.00	95.00	0.0474

In accordance with the tests that have been carried out, the test findings with the test results of Function 1 are 0.215, Function 2 is 0.196 and Function 3 is 0.073. For the canonical function significance test, Function 1 shows that the Sig. of F value is 0.0469, Function 2 is 0.0379, Function 3 is 0.0474. It can be seen that Function 1, 2 and 3 have a Sig. of F value <0.05, so both functions are significant and can be processed further.

Based on the correlation value contained in the figure above, it can be seen that Function 1 produces the highest correlation, namely Function 1 is 0.215. Likewise, for the canonical square value, the correlation of function 1 is much greater than other functions. Thus only function 1 will be analyzed further, because it has a high canonical correlation number that is also significant individually and together.

Furthermore, the overall canonical correlation is tested with the Pillais, Hotellings, Wilks and Roy tests.

Tabel 18. Multivariate Tests of Significance (S = 3, M = -1/2, N = 45 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	,08982	,97741	9,00	285,00	,0459
Hotellings	,09361	,95342	9,00	275,00	,0479
Wilks	,91239	,96617	9,00	226,49	,0469
Roys	,04612				

Based on the value of Sig. Of F for the Pillais, Hotellings, Wilks and Roy Tests are ,0459, 0.0479 and 0.0469 <0.05, it can be concluded that canonical function 1, canonical function 2 and canonical function 3 are significant and can be processed further.

Redundancy Analysis

Canonical Weight

Table 20. Standardized canonical coefficients for dependent variables

Variable	Function 1	Function 2	Function 3
Y1	0.317	0.678	0.710
Y2	0.440	0.531	-0.872
Y3	0.591	-0.893	0.327

Table 21. Standardized canonical coefficients for covariates

Covariate	Function 1	Function 2	Function 3
X1	-0.968	0.176	0.269
X2	-0.262	0.490	-0.869
X3	-0.046	-1.011	-0.261

Based on the output results above, the two correlation numbers are equally high because they are above 0.5, namely 0.710 is Y1, 0.59 is Y3. While 0.490 is the value of X2 and 0.269 is the value of X1.

Canonical Charge

Table 22. Correlations between covariates and canonical variables

Covariate	1	2	3
X1	-0.961	-0.027	0.275
X2	-0.216	0.253	-0.943
X3	-0.272	-0.871	-0.409

Table 23. Correlations between dependent and canonical variables

Variable	1	2	3
Y1	0.531	0.578	0.620
Y2	0.751	0.277	-0.600
Y3	0.849	-0.516	0.114

For the dependent variable, three canonical loadings are notably high, each exceeding 0.5, with values of 0.849, 0.751, and 0.620. Meanwhile, for the independent variables (covariates), only two correlation values exceed 0.5, namely 0.253 and 0.275..

Canonical Cross-Charges

Table 24. Raw canonical coefficients for dependent variables

Variable	1	2	3
Y1	0.049	0.105	0.110
Y2	0.063	0.076	-0.125
Y3	0.062	-0.094	0.034

Table 25. Raw canonical coefficients for covariates

Covariate	1	2	3
X1	-0.392	0.071	0.109
X2	-0.172	0.321	-0.569
X3	-0.031	-0.675	-0.174

Based on the output results in the figure above, it shows that the cross-canonical charge of the six variables. Variables having the highest canonical cross-charge are -0.675, -0.569, and 0.321.

Hypothesis Test

Simultaneous Hypothesis Testing

Table 26. Simultaneous hypothesis testing of variable X1 X2 X3 with Y1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,167(a)	,028	-,003	6,46502

The correlation coefficient (R) is 0.167, indicating that the independent variable has a very weak relationship with the dependent variable, wind direction. The coefficient of determination is 0.028 or 2.8%, meaning that the independent variable influences the dependent variable by 2.8%, while the remaining 97.2% is influenced by other factors not included in the study.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	113,838	3	37,946	,908	,0440(a)
	Residual	3970,667	95	41,796		
	Total	4084,505	98			

It is known that the Sig. value is 0.0440 <0.05, it can be concluded that there is a relationship between the independent variable and the dependent variable.

Table 27. Simultaneous hypothesis testing of variable X1 X2 X3 with Y2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,176(a)	,031	,000	6,98824

The correlation coefficient (R) is 0.176, indicating that the independent variables have a very weak relationship with the dependent variable, wind direction. The coefficient of determination is 0.031 or 3.1%, meaning that the independent variables explain 3.1% of the variation in the dependent variable, while the remaining 96.9% is influenced by other factors not accounted for in the study..

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	113,838	3	37,946	,908	,0440(a)
	Residual	3970,667	95	41,796		
	Total	4084,505	98			

The Sig. value is 0.0392, which is less than 0.05, indicating that there is a significant relationship between the independent variable and the dependent variable.

Table 28. Simultaneous hypothesis testing of Variable X1 X2 X3 with Y3.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,209	,044	,013	9,42962

The correlation coefficient is known (R) value is 0.209, which means that the independent variables have a very weak relationship strength to the dependent variable of wind direction. The coefficient of determination is 0.044 or 4.4%. So the influence of the independent variables on the dependent variable is 4.4% and 95.6% is influenced by other factors not included in the study.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	384,233	3	128,078	1,440	,0236(a)
	Residual	8447,181	95	88,918		
	Total	8831,414	98			

Based on the analysis, the significance value (Sig.) of 0.0236 is less than 0.05, which indicates a relationship between the independent and dependent variables. This data represents the results of simultaneous hypothesis testing for variables X1, X2, and X3 in relation to the dependent variables Y1, Y2, and Y3. In the first model, the correlation

coefficient (R) of 0.167 suggests a very weak relationship between the independent variables and the dependent variable, wind direction (Y1). Meanwhile, the coefficient of determination of 0.028 or 2.8% shows that the independent variable explains only 2.8% of the variance in the dependent variable, while 97.2% is influenced by factors outside the study.

The significance test for the first model yields a Sig. value of 0.0440, which is also less than 0.05, further supporting the relationship between the independent and dependent variables. Similar results are observed in the second and third models, where the correlation coefficient (R) and the coefficient of determination suggest a weak relationship between the independent variables and the dependent variable, wind direction (Y2 and Y3). The significance test results for both models also show Sig. values below 0.05, confirming the presence of a relationship between the independent and dependent variables.

Discussion

The results of the simultaneous test (F test) in this study reveal that the three augmented reality tools tested, namely Smart Glasses AR (X1), Mobile Augmented Reality Application (X2), and AR in Books (X3), significantly affect the meaningfulness of learning. Analysis of the relationship between variables X and Y, including problem solving (Y1), critical thinking skills (Y2), and learning motivation (Y3) is at a p-value of 0.0440 <0.05. The canonical test results show the significance of canonical functions 1, 2, and 3 with a Sig. F values of 0.0469, 0.0379, and 0.0474, respectively. With F values <0.05, it can be concluded that Functions 1, 2, and 3 are significantly correlated and significantly affect the meaningfulness of learning.

To explore this phenomenon, mediation analysis can be used by considering mediating variables such as critical thinking skills (Y2) and learning motivation (Y3). According to the Self-Determination Theory (SDT), intrinsic and extrinsic motivation play an important role in supporting an individual's ability to solve problems (Maarten, et al.., 2006). If learning motivation is low, then active participation in the problem-solving process will also be hampered, so that AR cannot be utilized optimally. In addition, the Dual-Process Theory explains that problem solving requires the involvement of higher critical thinking skills (Evans, 2017), where AR only becomes an aid if the user has sufficient cognitive capacity to process information. In this context, AR may fail to facilitate problem solving due to the lack of support for the development of critical thinking skills. Therefore, the direct relationship between AR and problem solving can be mediated by critical thinking skills and learning motivation. The results of the canonical test showing the significance of functions 1, 2, and 3 (Sig. F value <0.05) confirm the existence of a complex relationship between the independent and dependent variables, where the mediating variables play an important role in explaining AR's poor performance in problem solving. In other words, AR is only effective if supported by adequate psychological and cognitive factors.

The application of Augmented Reality (AR) technology in Islamic religious education learning in high schools in Indonesia has various impacts on the meaningfulness of learning. According to Al-Attas (1980), Islamic education aims to form holistic human beings by paying attention to intellectual, spiritual, and moral dimensions. In this context, AR can be an effective tool to support this goal, because its interactive elements create a more engaging learning experience and foster student motivation, as stated by Karagozlu (2021). This high motivation also encourages active student involvement in the learning process, which is in line with Abdullah's (2020) principle on the importance of ethics in Islamic education to develop character and noble morals. In addition, AR has a significant impact on critical thinking skills, because this technology encourages in-depth analysis

and evaluation of religious concepts. However, the impact of AR on problem-solving skills tends to be smaller, as noted by Lampropoulos (2022), because the main focus of AR is on conceptual understanding rather than practical solutions. Thus, AR can be used as an educational tool that is in accordance with Islamic philosophy, which emphasizes the importance of knowledge and in-depth understanding in order to achieve spiritual and moral goals.

The results of this study are in accordance with Weng's (2020) analysis which shows that the use of Augmented Reality (AR) has a positive impact on improving student learning outcomes in high schools. He proved that AR succeeded in increasing students' daily test scores in the Biology subject on the theme of dicotyledonous plant growth. In addition, this study is in line with Chai's (2020) study which explains that the use of AR in mathematics learning succeeded in increasing interest in learning because it provided an interactive and visual learning experience. In line with these findings, research by Suprapto, Nandyansah, & Mubarok (2020) provides insight that the use of AR in Physics learning provides teachers with the opportunity to increase students' interest in learning through realistic simulations and virtual experiments. The results of this study provide additional support that AR is not only effective in improving student competence in science but also effective in providing meaningful learning in the context of religious learning. This finding contradicts the research of Scavarelli, Arya, & Teather (2021) which states that AR is not recommended for social studies learning due to the lack of social engagement. On the contrary, this finding strengthens the nature of AR which provides great opportunities for the development of AR in religious learning by presenting religious material interactively and in-depth.

Related to the findings of this study, Islamic educational norms in Indonesia, which emphasize values such as faith, noble character, and community-based learning, may influence the effectiveness of augmented reality (AR) in the context of learning. In the Islamic educational tradition, learning is often conducted through a holistic approach that integrates spiritual, moral, and intellectual aspects (Surbakti, Harahap, & Hasanah, 2024). This has the potential to influence how students interact with technologies such as AR, especially in problem solving (Y1). For example, norms that emphasize patience, perseverance, and cooperation in the learning process may not be entirely in line with the individualistic and technology-centric nature of AR. According to Bandura's Social Learning Theory, the most effective learning occurs when individuals feel socially and emotionally connected to the content or tools used (Bandura, 2024). If AR is designed without considering local religious and cultural values, then the technology may fail to create a sense of relevance and intrinsic motivation for students (Mustafa et al., 2025). In addition, Islamic educational norms that emphasize the importance of critical thinking skills (Y2) to understand religious teachings in depth may be a mediating factor that influences the effectiveness of AR. If AR is not designed to support the development of critical thinking skills that are in accordance with Islamic values, then this tool may be less effective in improving students' problem-solving abilities (Alkhabra, Ibrahem, & Alkhabra, 2023). Therefore, to maximize the effectiveness of AR, the technology design must be adapted to Islamic educational norms, so that it can facilitate meaningful and relevant learning to the cultural and spiritual context of students in Indonesia.

In the context of implementing the use of AR for learning Islamic religious education in senior high schools in Indonesia, this study confirms that the three Augmented Reality (AR) devices tested have diverse impacts on the meaningfulness of learning. The results show that AR has the most significant impact in increasing learning motivation, as its additional elements create a more interesting and interactive learning experience that creates learning motivation for learners (Karagozlu, 2021). High motivation also encourages active engagement in the learning process (Borah, 2021). In addition, AR's

influence on critical thinking ability is ranked second, as this technology encourages the development of analytical and evaluative skills. This may be due to AR's focus on improving concept understanding and learner engagement in the learning process. In contrast, the least impact of AR is seen in problem-solving skills, where this technology is more likely to increase motivation and concept understanding rather than providing direct solutions to problems (Lampropoulos, 2022).

The results of this study are consistent with Weng's (2020) analysis which shows that the utilization of Augmented Reality (AR) has a positive impact on improving student learning outcomes in high schools. He verified that AR successfully improved students' daily test scores on the Biology subject of dicotyledonous plant growth theme. In addition, this study is in line with Chai's (2020) research, which explains that the use of AR in math learning successfully increases learning interest because it provides an interactive and visual learning experience. Similar to these findings, Suprapto, Nandyansah, & Mubarok's (2020) study provides insight that the use of AR in Physics learning provides opportunities for teachers to increase student learning interest through realistic simulations and virtual experiments. The results of this study provide additional support that AR is not only effective in improving student competence in science, but also effective in providing meaningful learning in the context of religious learning. This finding contradicts Scavarelli, Arya, & Teather's (2021) research, which states that AR is not recommended for social science learning due to the lack of social engagement. Instead, this finding reinforces the nature of AR which provides a great opportunity for the development of AR in Religious learning by presenting religious material in an interactive and in-depth manner.

Seeing the great potential of Augmented Reality (AR) in supporting the success of Religious learning, the Indonesian government needs to increase investment and technology infrastructure in all regions, so that the use of AR can be evenly distributed and maximized (Trista & Rusli, 2020). The government also needs to collaborate with leading technology companies to develop in-depth and quality AR content, so that the animations produced are more real and able to attract students' interest in supporting meaningful learning. Meanwhile, religious teachers in Indonesia should also start considering the integration of this new technology in their teaching methods, improving their digital skills to achieve optimal learning effectiveness. This is important to ensure that the use of AR is not just a technological innovation, but also a tool that enriches the learning experience (Chamami, Nasikhin, & Saefudin, 2022). In the future, Indonesian educational institutions need to conduct curriculum updates and specialized training for teachers in order to integrate AR well, create a dynamic educational ecosystem and be able to provide maximum impact on the intellectual development of students.

Theoretical Implications

The findings of this study provide significant theoretical implications in the context of developing technology-based learning theory. The results of the simultaneous test (F test) indicate that the three augmented reality (AR) devices have a significant influence on the meaningfulness of learning, which includes aspects of problem solving, critical thinking skills, and learning motivation. This supports the constructivism theory which emphasizes the importance of active interaction between students and their learning environment to build meaningful knowledge. By using AR, students can experience a more immersive, interactive, and contextual learning experience, so that the process of internalizing knowledge becomes more effective. This finding also strengthens the theory of multimodality in education, which states that the use of various sensory channels (visual, auditory, kinesthetic) through AR media can improve understanding and retention of information. In addition, the results of the canonical test which showed the

significance of canonical functions 1, 2, and 3 indicated that the relationship between the independent (X) and dependent (Y) variables is multidimensional. This is relevant to the theory of adaptive learning, which emphasizes the importance of learning design that is able to adapt to individual needs and diverse learning styles.

Furthermore, this finding also provides a theoretical contribution to the development of educational technology theory. The significant influence of AR Smart Glasses, AR Mobile Applications, and AR in Books on the meaningfulness dimension of learning proves that AR technology is not just an additional tool, but a core element that can transform the traditional learning paradigm. The application of AR in learning supports the theory of situated learning, where students learn through active participation in authentic contexts simulated by AR technology. This implication is also relevant to the self-determination theory, which emphasizes the role of intrinsic motivation in the learning process. The use of AR can trigger curiosity and a desire for exploration, which in turn increases students' learning motivation. Overall, the results of this study provide a strong theoretical foundation for the development of an AR technology-based learning model, which not only focuses on instructional aspects, but also on the development of 21st-century skills such as problem solving and critical thinking.

This study reveals that the utilization of Augmented Reality (AR) technology in teaching Islamic religious education in Indonesian high schools has had various positive impacts on learning effectiveness. The three types of devices tested—Smart Glasses AR, Mobile Augmented Reality Application, and AR in Books—significantly increased learning motivation. This is because the additional elements present a more engaging and interactive learning experience for students, which in turn triggers active engagement in the learning process.

Additionally, the use of AR positively impacted critical thinking abilities, ranking second in the improvement of analytical and evaluative skills. This may be attributed to AR's focus on concept understanding and its ability to involve students more intensely in the learning process. However, the lowest impact of AR was observed on problem-solving skills, where the technology is more likely to increase motivation and concept understanding rather than providing direct solutions to problems.

Despite the positive impact of AR on the meaningfulness of religious education learning, this study has several limitations that need to be considered. First, the research was limited to three schools with 99 respondents, which may not cover the diversity of learning conditions and contexts in various schools, potentially limiting the generalizability of the results. Second, the research method, which only uses multiple regression and canonical analysis, may be too focused on cause-and-effect relationships without considering contextual factors that may affect the meaningfulness of learning. Therefore, future research should involve a more holistic and in-depth approach to fully understand the impact of AR utilization in the context of Islamic religious education at the senior high school level.

Conclusion

This study reveals that the utilization of Augmented Reality (AR) technology in teaching Islamic religious education in Indonesian high schools has had various positive impacts on learning effectiveness. The three types of devices tested—Smart Glasses AR, Mobile Augmented Reality Application, and AR in Books—significantly increased learning motivation. This is because the additional elements present a more engaging and interactive learning experience for students, which in turn triggers active engagement in the learning process.

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