Optimizing High School Students' Interest and Motivation in Economics Learning Through the Development of Flashcard Based Augmented Reality Learning Media

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Abstract
The research aims to develop flashcard learning media based Augmented Reality (AR) as an effort to encourage the realization of Sustainable Development Goals (SDGs) point 4 on quality education. The development of AR flashcard learning media is expected to optimize students' interest and motivation in learning economics in the classroom. The development model used in this study is the ADDIE Model. This model includes the stages of analysis, design, development, implementation, and evaluation. Data collection techniques used are qualitative and quantitative. Qualitative data comes from observations and interviews related to the analysis of the needs of learning media products to be developed. Quantitative data from questionnaires before and after media implementation. The effectiveness of AR Flashcard Media on student interest and motivation was measured using the Wilcoxon and Mann Whitney Tests because based on the results of the normality test it was known that the data were not normally distributed. The results of the study prove that AR Flashcard Media can optimizing student interest and motivation in economic lesson.

1. Introduction

As stipulated in Government Regulation No. 22 of 2016 about Elementary and Secondary Education Processes Standards in Chapter I point 13, namely the utilization of information and communication technology to improve the efficiency and effectiveness of learning (Standar Proses Pendidikan Dasar Dan Menengah, 2016). In practice, various innovations are needed to continuously improve and strive for the best learning process in order to realize meaningful learning (meaningful learning) in order to encourage the realization of Sustainable Development Goals (SDGs) point 4 on quality education. One factor that plays a significant role in realizing quality learning is the selection of appropriate and effective learning media. As technology advances, opportunities arise to utilize existing technological advances as learning media in the classroom. Therefore, research related to the development of technology-based learning media is important.

In economics learning, teachers often face challenges in maintaining students' attention and engagement. Economics subjects contain many abstract concepts, such as inflation, market mechanisms, demand and supply, economic systems, and financial activities, which are difficult for students to visualize through conventional teaching methods. As a result, students frequently experience boredom, lack concentration during lessons, and show low motivation to participate actively in the learning process. At the same time, most high school students are highly familiar with smartphones and digital technology in their daily lives. This condition provides an opportunity for educators to integrate smartphone-based learning media into economics instruction in order to create more interactive and attractive learning experiences.

One of technology that has strong potential to support economics learning is Augmented Reality (AR). AR technology is one of technology that can be utilized as a learning medium in the classroom because it can be accessed from students' smartphones. This technology takes the form of an application that can combine the real world and the virtual world into three dimensions and can be projected simultaneously (Dewi & Anggryani, 2020). AR technology helps minimize boredom and ineffectiveness in delivering material during learning activities and can add value to students' smartphones, in fact in the 4.0 era there is shifting to Android-based learning media, such as AR. Android-based media has high potential and is effective in implementing the learning process (Degner et al., 2022).

Previous studies have shown that AR-based learning media can improve the quality of learning experiences and increase students' engagement in classroom activities. Research by Damayanti and Putra

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(2024) and Habashi (2023) found that AR learning media contribute positively to students' learning outcomes. In addition, López-Faican and Jaen (2020) explained that AR-based learning can create positive emotions, enjoyment, and curiosity among students, which are closely related to learning motivation. Omar et al. (2023) also suggested that further studies should focus more specifically on the influence of AR on students' motivation and interest during the learning process.

The novelty of this study is its focus on the learning process rather than learning outcomes. It is because previous studies on AR learning media have predominantly focused on cognitive learning outcomes (Damayanti & Putra, 2024; Habashi, 2023), rather than affective aspects of learning process, particularly students' interest and motivation. Furthermore, the development of AR learning media in economics subjects remains limited compared to other fields of study. This gap is important because economics learning requires visualization and contextualization of real-life phenomena to help students understand abstract economic concepts more effectively. Therefore, this study focuses on the development of Augmented Reality-based flashcard learning media for economics subjects and examines its role in optimizing high school students' interest and motivation in economics learning. This study is expected to contribute to the development of innovative digital learning media that support more engaging, interactive, and student-centered economics learning processes. This research is also a continuation of Fauziah and Sulisworo (2021), whose research on AR learning media in physics provided suggestions for future AR media researchers to develop AR learning media in other subjects.

The specific objective of this study is to provide an overview of the implementation of AR learning media development in economics subject at high school student's in order to optimizing student interest and motivation in classroom. This study's contribution can serve as a reference and consideration in determining the best solutions and strategies for economics learning at the high school level.

2. Method

This study employed the ADDIE development model to develop Augmented Reality (AR)-based flashcard learning media for economics subjects. The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation (see Figure 1). This model was selected because it is systematic, flexible, and allows continuous revision and evaluation at each stage of the development process (Safitri & Aziz, 2022). The implementation flow of the ADDIE model in this study is first At the analysis stage, researcher identifies learning needs and student characteristics and their behaviour during lesson in the classroom especially in economic lesson. During observation researcher discover taha most students have smartphones. And sometimes play with their smartphone during class.

Second, at the design stage, the researchers designed the structure, content, and interface of the AR flashcard learning media. Learning materials, visual elements, markers, and AR interactions were adjusted to economics topics and students' characteristics. Furthermore, research instruments such as questionnaires for measuring students' interest and motivation were also designed. Third, at the development stage, the AR flashcard media were produced and validated by media experts and subject matter experts to assess the quality, feasibility, and appropriateness of the product before implementation. Revisions were conducted based on suggestions from validators to improve the effectiveness and usability of the media.

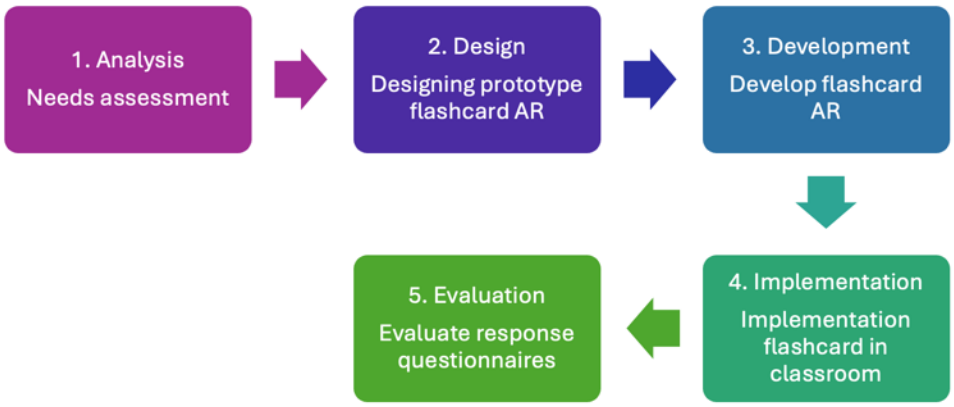

Figure 1. Research Flow

Fourth, at the implementation stage, the developed media were applied in economics learning through a quasi-experimental design. The quasi-experimental design was used because the researchers could not randomly assign students into groups due to existing classroom arrangements in schools. Therefore, intact classes were used as experimental and control groups to compare the effectiveness of the learning media. The study involved two experimental groups and two control groups, with each class consisting of approximately

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33–35 students. The experimental groups used AR flashcard learning media, while the control groups used conventional learning media. The subjects of this research were 10th grade high school students. The characteristics of 10thgrade students generally accustomed to using smartphones and digital media in their daily lives, making them more responsive to technology-based learning media such as Augmented Reality (AR).

Fifth, at the evaluation stage, the effectiveness of the AR flashcard learning media was analyzed based on the results of students' interest and motivation questionnaires. Data were collected through pre-test and post-test questionnaires measuring students' interest and motivation in economics learning before and after the implementation of AR flashcard media. Interest indicators refer to Slameto (2015) which consist of: 1. Feelings of pleasure, 2. Student involvement, 3. Interest and 4. Student attention. Learning motivation indicators refer to Sardiman (2018), namely: 1) Diligence in facing tasks, 2) Persistence in the face of difficulties (not easily discouraged), 3) Demonstrates interest in various adult problems, 4) Prefers to work independently, 5) Gets bored quickly with routine tasks, 6) Can defend one's opinions, 7) Does not easily give up on beliefs and 8) Enjoys finding and solving problems effectively.

A normality test was first conducted to determine whether parametric or non-parametric statistical analysis should be used. The results showed that all pre-test and post-test data in both experimental and control groups had significance values lower than 0.05, indicating that the data were not normally distributed. Therefore, non-parametric statistical tests were employed using the Wilcoxon Signed Rank Test to analyze differences before and after treatment within groups, and the Mann–Whitney U Test to analyze differences between experimental and control groups.

3. Results and Discussion

3.1. Results

3.1.1. The Development of AR Flashcard Learning Media

This study developed AR flashcard learning media as a solution to increase high school students' interest and motivation in learning economics. This media was designed to visualize conceptual economics material more concretely through digital objects, animations, and additional information accessible via smartphone devices. The AR Flashcard learning media in this research was develop using the ADDIE model because ADDIE model has systematic and structured stages that can be adjusted with student needs and latest curriculum developments. The ADDIE development model consists of 5 development stages, namely:

3.1.1.1. The Analysis Stage

In the analysis stage, researcher identifies learning needs and student characteristics. Based on observations and interviews with economics teachers, it was found that: (1) Students show low interest in abstract economics material. (2) Interactive learning media capable of visualizing economic concepts in a concrete way are needed. (3) Students tend to enjoy playing with their phones in class. (4) The majority of students have fairly good devices and have internet data. (5) Students tend to enjoy and actively learn using digital learning media.

The summary of observation also showed in student need Questionnaire Results (see Table 1).

Table 1. Summary of Student Needs Questionnaire Results

No	Questionnaire	Percentage (%)	
		Yes	No
1	Have you heard about AR-based Flash card learning media?	16.41	83.59
2	Have your teachers ever used AR-based learning media in economics lessons in class?	19.53	80.47
3	Have your teachers ever used AR-based learning media to explain money material?	0.00	100.00
4	Do you need innovative learning media to help you understand money?	82.03	17.97
5	Do you agree if we design AR-based flashcard learning media?	86.72	13.28
6	Will learning economics be more interesting if you use Android-based learning media?	92.19	7.81

Furthermore, an analysis of student characteristics showed that most students are already accustomed to using smartphones and are interested in digital technology. Therefore, Augmented Reality-based media is considered suitable for use in economics learning.

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3.1.1.2. The Design Stage

In the design stage, the AR flashcard content was designed. There are 7 flashcards that cover the following seven subtopics on money as a means of payment: Definition of money, Characteristics of money, Functions of money, Types of money, History of money, Money as a means of payment, and Transformation of money in the digital era. The physical flashcards were designed using Canva. The front of the flashcard is designed for the sub-material title, and the back is for placing the AR QR marker or barcode, which will be scanned later. Additionally, the preparation of research instruments includes validation questionnaires from media experts, material experts, and student response questionnaires.

3.1.1.3. The Development Stage

In the development stage, focus on creating visual concepts for flashcards, AR markers, and 3D content relevant to the economics material on the assembler.edu platform. During the development stage, average validation value for each validator (validator from subject matter experts and media experts) was measured to assess the feasibility of the media that has been developed. Feasibility criteria based on the Table 2.

Table 2. Feasibility Criteria of Learning Media

No	Percentages	Description
1.	< 21%	Very unworthy
2.	21.00% - 40.00%	Not feasible
3.	41.00% - 60.00%	Feasible enough
4.	61.00% - 80. 00%	Feasible
5.	81.00% - 100.00%	Very feasible

Source: modified from Suharsimi (2020)

The validation results from subject matter experts shows that the questionnaire results from each material validator are 85.71% and 91.07%. Meanwhile, the total average validation is 88.39% (very feasible). It indicated that, from a subject matter expert's view, AR flashcards were very feasible and very suitable to use in the learning process. Furthermore, a validation from media experts is used to evaluate the appearance, interactivity, and ease of use of AR flashcard learning media. Based on the formula, the questionnaire results from each material validator are 92,31% and 94.23%. the total average validation = (92.31 + 94.23) / 2 x 100% = 93.27% (very feasible).

3.1.1.4. The Implementation Stage

The implementation stage was conducted in the experimental class, grade X from two public senior high school in Indonesia. The teacher acts as a facilitator, while students use the AR application through their devices by scanning the AR barcode on a physical flashcard. Students were divided into 7 groups. Each group received a flashcard for the different sub-themes related to money materials. Group 1 received a barcode for the material Definition of money, group 2 received a barcode Characteristics of money, group 3 received a barcode Functions of money, group 4 received a barcode Types of money, group 5 received a barcode History of money, group 6 received a barcode Money as a means of payment and group 7 received a barcode Transformation of money in the digital era. Each group was given 15 minutes to scan and study the media Then each group took turns scanning each barcode sequentially (see Figure 2).

Figure 2. Physical Flashcard AR Display in This Research

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After scanning the barcode in flashcard, student will be directed to web assembler.edu. and the student will be asked to allow permission then 3D object AR will appear like figure 3.

Figure 3. 3D AR Display on assembler.edu

The media also played an explanatory narrative according to the title listed on the flashcard. Students are supposed to listen to it well for better understanding. Also, there will be a choice if student want to place the animation or 3D object AR in their room or other places, they want by clicking Place AR Content then directing their smartphone camera toward the specific place they want. Students can evaluate their knowledge by answering the quiz by scanning barcode quiz (see Figure 4).

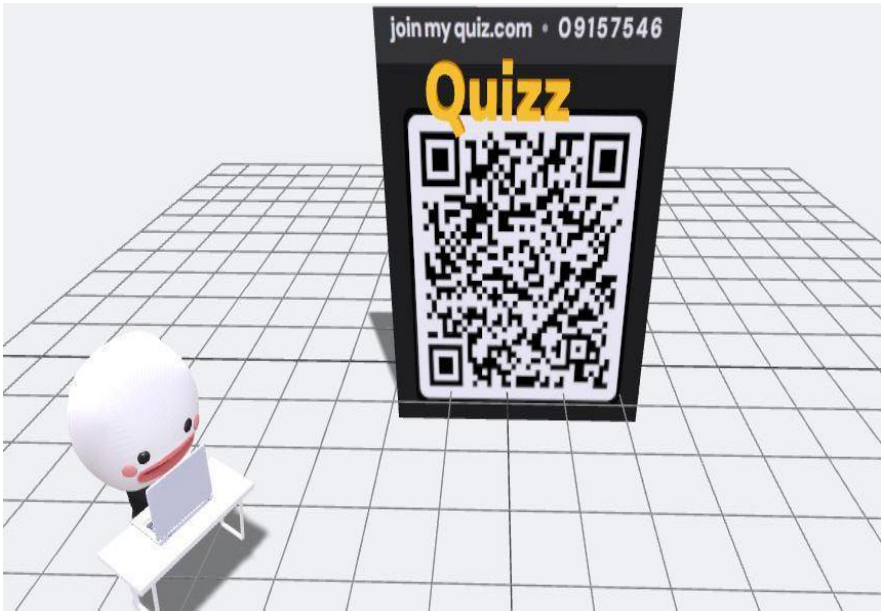

Figure 4. Quiz Display

3.1.1.5. The Evaluation Stage

The evaluation stage conducts to assess the overall quality and effectiveness of the AR flashcard learning media. As evaluation, we conduct a quasi-experimental research with a pretest-posttest control group design was used. Two experimental classes used AR flashcard media, while two control classes used conventional learning methods. The data collection instrument was a Likert scale 1-4 questionnaire that measured student's interest and motivation in learning economics before and after. Data analysis was carried out using statistical

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tests to compare interest and motivation scores before and after using AR flashcard in economics lesson on the topic of money as a means of payment, thus determining the level of effectiveness of the developed media.

3.1.2. Normality Test

A normality test was measure in this research to determine whether data in the experimental class and control class were normally distributed or not in order to determine the choice of statistical analysis technique to be used, whether parametric or non-parametric statistics. Based on result on Table 3, it is showed that all pre-test and post-test data in both the experimental and control groups had significance values < 0.05, indicating that they were not normally distributed. Therefore, effectiveness analysis was performed using non-parametric statistics with the Wilcoxon test and Mann-Whitney Test.

Table 3. Test of Normality Result

Tests of Normality							
	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Interest and motivation	Pre-Test Experiment (FAR)	.154	64	.001	.951	64	.013
	Post-Test Experiment (FAR)	.293	64	.000	.787	64	.000
	Pre-Test Control (Conventional)	.129	64	.010	.959	64	.033
	Post-Test Control (Conventional)	.307	64	.000	.824	64	.000
a. Lilliefors Significance Correction							

3.1.3. Wilcoxon Test

An analysis of the effectiveness of learning media was conducted to determine whether AR flashcard-based learning media could improve student interest and motivation. This effectiveness was analysed based on changes in scores before and after treatment in each research group. In this study Wilcoxon test was used to measure the difference between the pre-test and post-test on the interest and motivation questionnaire between the experimental class (AR Flashcard media) and the control class (conventional learning). The Wilcoxon test is a nonparametric statistical method often used in educational research to analyse significant differences between two groups of related data (Sari & Ahmad, 2025). This test aims to determine whether there is a significant improvement after students AR Flashcard media during the learning process. Based on Wilcoxon test result, it is proven the implementation of AR flashcard media learning has a positive and significant effect on in increasing student's interest and motivation in economic lesson in experiment class since Asymp sig 0.000 < 0.005 (see Table 4).

Table 4. Wilcoxon Test Result

Ranks				
		N	Mean Rank	Sum of Ranks
Post-Test Experiment - Pre-Test Experiment	Negative Ranks	0[a]	.00	.00
	Positive Ranks	62[b]	1953.00	1953.00
	Ties	2[c]		
	Total	64		
Post-Test Control - Pre-Test Control	Negative Ranks	12[d]	300.00	300.00
	Positive Ranks	35[e]	828.00	828.00
	Ties	17[f]		
	Total	64		
a. Post-Test Experiment < Pre-Test Experiment				
b. Post-Test Experiment > Pre-Test Experiment				
c. Post-Test Experiment = Pre-Test Experiment				
d. Post-Test Control < Pre-Test Control				
e. Post-Test Control > Pre-Test Control				
f. Post-Test Control = Pre-Test Control				

Test Statistics[a]		
	Post-Test Experiment - Pre-Test Experiment	Post-Test Control - Pre-Test Control
Z	-6.886[b]	-2.817[b]
Asymp. Sig. (2-tailed)	.000	.005
a. Wilcoxon Signed Ranks Test		
b. Based on negative ranks.		

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3.1.4. Mann Whitney Test

The hypothesis for Mann Whitney test are: H0 = there is no significant difference between experimental and control group; H1 = there is significant difference between experimental and control group. Based on the calculation results (Ranks), the Experimental Class which use AR Flashcards media learning during economic lesson in classroom has a Mean Rank value of 71.75 (see Table 5). Meanwhile the Control Class has a Mean Rank value of 57.25. This shows that the level of interest and motivation to learn among students in the experimental class is higher than in the control class. It also showed that the significance value is 0.016, which is bellow < 0.05, it means H1 accepted and can be concluded that there is a significant difference between the interest and learning motivation of students in the experimental class and the control class.

Table 5. Mann Whitney Test Result

Ranks				
	Class	N	Mean Rank	Sum of Ranks
Interest_and_Motivation	Experiment Class (FAR)	64	71.75	4592.00
	Control Class (Konvensional)	64	57.25	3664.00
	Total	128		

Test Statistics[a]	
	Interest_and_Motivation
Mann-Whitney U	1584.000
Wilcoxon W	3664.000
Z	-2.403
Asymp. Sig. (2-tailed)	.016
a. Grouping Variable: Class	

3.2. Discussion

The results of this study proven important empirical support for modern educational theories that promote that learning media based technology can enhancing student involvement. The important thing after introducing AR flashcard media to student are as demonstrated by the Wilcoxon test that showed that AR flashcard media learning has a positive and significant effect on in increasing student's interest and motivation in economic lesson in experiment class. The result same page as constructivist learning theory, which asserts that learners actively build knowledge through engaging and significant experiences. The incorporation of augmented reality (AR) seems to establish an environment by turning abstract economic ideas into more tangible and visually appealing forms. These findings align with Annail et al. (2025), indicating that students engaged with AR showed higher motivation levels than those instructed through conventional methods. The application of AR increased students' interest, involvement, and interaction in lessons, providing a more immersive and dynamic learning experience. This alignment indicates an increasing collection of proof endorsing AR as a useful educational resource. A study by Arymbekov et al. (2024) indicates that AR media greatly enhances students' motivation and excitement for learning the topic.

Research by Li et al (2024), indicated that the teaching with AR fosters better cognitive construction and emotional acceptance than traditional methods. From the perspective of the Educational Technology framework, the findings reinforce the notion that digital innovation can bridge gaps between student learning preferences and instructional delivery, particularly in subjects often perceived as theoretical or less engaging, such as economics. Factors such as digital literacy, access to technology, and prior learning experiences could mediate the effectiveness of AR learning media in enhancing interest and motivation students.

The Mann-Whitney test further strengthens the argument by demonstrating a statistically significant difference between the experimental and control groups, with higher mean ranks in the experimental class. This not only confirms the effectiveness of AR flashcards but also suggests that traditional teaching methods may be insufficient in addressing diverse student engagement needs in modern classrooms. Eventually same as result of this study, the study of Asiah et al. (2025) concluded that Augmented Reality (AR) media significantly enhances students' learning interest and motivation. Mahendra et al. (2025) state that that Augmented Reality (AR) significantly enhances students' learning interest and motivation. This innovative approach not only increases interest but also enriches the overall learning experience, highlighting the effectiveness of AR in education. These results are the same as research by Kurniawan and Kusuma (2021) which concluded that the use of AR-based learning applications has resulted in a significant increase in students' interest in learning.

The effectiveness of Augmented Reality (AR) learning media in this study can be explained through several learning mechanisms. AR transforms abstract economics concepts into concrete and interactive visualizations through three-dimensional objects, animations, and real-time digital interactions. This mechanism helps students understand complex economic materials more easily because they can directly observe and interact with learning content rather than only receiving verbal explanations from teachers. In addition, AR creates immersive and multisensory learning experiences that combine visual, auditory, and interactive elements simultaneously. These interactive experiences stimulate students' curiosity, attention, and active participation

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during classroom activities, which ultimately increase their learning interest and motivation. AR also supports contextual learning by connecting economics concepts with real-life situations familiar to students, making the learning process more meaningful and engaging.

However, the effectiveness of AR learning media may also be influenced by several moderating factors. One important factor is access to technology, including smartphone availability, device specifications, internet connectivity, and school technological facilities. Students with adequate technological access are more likely to experience smoother and more optimal AR-based learning. Another important moderating factor is digital literacy. Students who are familiar with smartphones, digital applications, and technology-based learning environments tend to adapt more easily to AR learning media and maximize its educational benefits. Conversely, students with limited digital skills may experience difficulties in operating AR applications, which can reduce the effectiveness of the learning process. Therefore, the successful implementation of AR learning media depends not only on the technology itself but also on students' technological readiness and learning environments.

Importantly, this study contributes to the existing literature by addressing a specific research gap namely, the application of AR technology in economics education, which remains relatively underexplored compared to STEM fields. By evidencing its positive impact on both interest and motivation, the study offers new insights into how AR can be adapted beyond science-based disciplines to enhance learning outcomes in social sciences.

Rather than merely validating prior findings, this research advances scholarly understanding by contextualizing AR within economics education and highlighting its potential as a transformative instructional tool. It underscores the need for educators to adopt innovative, student-centered approaches while also considering individual learner differences to maximize the benefits of emerging technologies.

3.3. Implications

Overall, this research makes a significant contribution regarding the impact of AR-based learning on optimizing student motivation and interest. In practical implications, the effectiveness of using AR-based flashcard learning media has been empirically proven to increase student interest and motivation. Therefore, teachers should consider integrating augmented reality technology into classroom instruction, particularly in subjects like economics, which are often considered abstract. Teachers can adopt AR-based learning media to diversify teaching strategies, accommodate different learning styles, and create a more student-centered learning environment, thereby increasing student participation in the classroom.

From theoretical implications, the results of this research strengthen constructivist learning theory. These findings provide empirical support for the argument that knowledge is not simply transferred from teacher to student but is constructed by students themselves through experience, interaction, and reflection. Furthermore, this research demonstrates that AR-based flashcard learning media can be applied in social science domains such as economics.

From policy implications, the results of this study can serve as a reference for educational institutions to support the adoption of innovative learning technologies to enhance the learning quality. Policymakers can use these findings to justify investments in digital infrastructure, teacher training, and the development of AR-based educational resources. Integrating AR into national or institutional curricula can help improve the overall quality of learning and student engagement.

3.4. Limitations

This study's limitations lie in the use of non-parametric statistical tests due to the non-normal distribution of the data. While the Wilcoxon and Mann-Whitney tests are appropriate in this situation, given the respondents' naturally varying characteristics, non-parametric statistical tests generally have lower statistical power than parametric statistical tests

4. Conclusion

AR flashcard learning media that development in this research using ADDIE Model development was suitable for use in economics lessons it is proven by the results of the feasibility test that show AR flashcard learning media were very feasible to adopt and use it in economic lesson. Meanwhile, for the effectivity of AR flashcard learning media in optimizing student's interest and motivation based on Wilcoxon test result, it is proven that the use of AR flashcard media learning has a positive and significant effect on in increasing student's interest and motivation in economic lesson in experiment class. And also based on the Mann Whitney test results, there was a significant difference in student interest and learning motivation between the experimental class that used AR Flashcard media and the control class that used conventional learning methods. AR Flashcard media proved to be more effective in increasing student interest and learning motivation. The result of this

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reseach also discover a promising innovation with the potential to significantly enhance students' interest and motivation through AR flashcard learning media.

Based on the result, suggestion for further researchers are to combine the influence of implementing AR learning media both on learning outcomes and learning process in order to give more comprehensive perspective related development learning media based AR. The further researchers must consider the availability of good internet facilities in the schools to be studied because the implementation of AR-based learning media in classroom requires good internet connectivity.

Author Contributions

The authors contributed collaboratively to the development and completion of this study, with each playing distinct yet complementary roles. The first author was primarily responsible for conceptualizing the research, formulating the research problem, and designing the study framework, including the development of the AR flashcard learning media. This author also led the data collection process and conducted the initial data analysis. The second author contributed to the methodological refinement and validation of the research instruments, as well as supporting the statistical analysis and interpretation of the results. The third author was responsible for supervising the overall research process, providing critical revisions to the manuscript, and ensuring the academic quality and coherence of the study.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that AI were used only to improve readability and language under strict human oversight; no content, ideas, analyses, or conclusions were generated by AI.

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