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Development of Augmented Reality Integrated Google Sites Multimedia to Enhance Elementary School Students' Understanding of the Food Chain Concept

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Abstract: This study aims to develop and evaluate Augmented Reality (AR)-based learning multimedia integrated with Google Sites to enhance the understanding of the food chain concept in elementary schools. The study employs the Research and Development (R&D) method using the ADDIE model. This development is evaluated through needs analysis, expert validation, effectiveness testing, and analysis of student responses to determine the extent to which the research findings address the research questions. The needs analysis was conducted through interviews with students and teachers and analyzed using content analysis with the stages of open coding, axial coding, and selective coding. The analysis results indicate that students and teachers have difficulty understanding the food chain concept due to the limitations of interactive and visual learning media. Therefore, the development of AR-based multimedia is necessary to help students visualize the concept more concretely. The developed multimedia has been validated by media experts, content experts, and practitioners using the V Aiken index, with the assessment results categorized as "Feasible" in terms of content, graphics, and media aspects. Effectiveness testing was conducted using the Effect Size (Cohen's d) calculation, yielding a value of 1.163563, which falls into the large effect category. These results indicate that the use of AR-based multimedia on Google Sites significantly improves students' understanding of the food chain concept compared to conventional methods. Student responses were analyzed descriptively with categorization through SPSS, covering aspects of perceived usefulness, ease of use, behavioral intention, and attitude towards the media. The results show that 100% of respondents fall into the high acceptance category, with students stating that the multimedia is beneficial, easy to use, and engaging. Thus, Augmented Reality-based learning multimedia integrated with Google Sites is proven to be feasible, effective, and well-received in enhancing the understanding of the food chain concept in elementary schools.

Keywords: Augmented Reality, Multimedia Learning, Food Chain.

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INTRODUCTION

Elementary education plays a crucial role in building students' cognitive, affective, and psychomotor foundations. One of its essential objectives is to foster comprehensive development through relevant and contextual learning experiences (Sulianto, 2008). In line with Indonesia's Kurikulum Merdeka (SK BSKAP No.33, 2022), the subject Ilmu Pengetahuan Alam dan Sosial (IPAS) introduces students to key environmental concepts,

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including food chainsan area vital for understanding ecosystem balance (Kumala, 2016). Despite its importance, food chain material remains challenging for many elementary students. Research shows that limited use of interactive and visual learning media hinders students' comprehension of complex ecological relationships (Sinaga, 2023). The dominance of static images and textbooks restricts students' ability to visualize energy flow within ecosystems, leading to fragmented understanding (Armansyah, et al, 2019). Moreover, there is a lack of technology-based interventions that offer immersive, engaging learning experiences in this domain. The rapid advancement of educational technology particularly Augmented Reality (AR) presents new opportunities to address these challenges. AR can enhance science education by enabling students to experience interactive, real-world simulations of biological processes, including the food chain (Endra,et al, 2020). Previous studies confirm the pedagogical potential of AR in promoting student engagement and conceptual understanding (Situmorang, et al, 2019). However, its implementation in Indonesian elementary schools remains limited due to constraints such as infrastructure readiness, teacher preparedness, and a lack of locally relevant content (Liliana, et al, 2023). To bridge this gap, this study aims to develop and evaluate AR-integrated multimedia hosted on Google Sites, focusing on the food chain concept in fifth-grade science education. Unlike conventional digital materials, this innovation incorporates QR-code-accessible AR content to support flexible, visual, and student-centered learning. Supporting findings from (Rizaldi, et al, 2020) demonstrated that AR-based IPAS learning tools using Assemblr Edu significantly enhanced critical thinking and retention in elementary settings. These insights underline the relevance and potential of this research in advancing immersive science education aligned with current curriculum goals. Accordingly, this study investigates (1) the instructional needs for AR-integrated Google Sites multimedia, (2) its feasibility in terms of content, media, and graphics, (3) its effectiveness in improving food chain concept comprehension, and (4) student responses toward the multimedia. This research contributes to the growing field of technology-enhanced learning in primary education, offering a scalable and context-sensitive model for digital science instruction.

METHOD

This study employed a Research and Development (R&D) approach using the ADDIE model (Analyze, Design, Develop, Implement, and Evaluate). The model was selected to guide the development and evaluation of multimedia learning materials integrated with Augmented Reality (AR) via Google Sites, with a focus on the topic of food chains for fifth-grade elementary school students.

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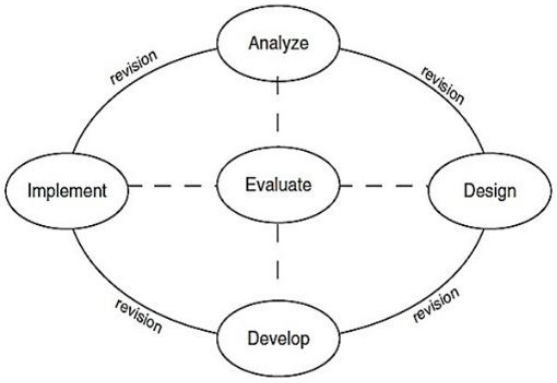

Figure 1. ADDIE Model Development Flow

Analyze Stage The needs analysis was conducted through interviews with teachers and students at an elementary school. The data were analyzed using content analysis techniques, including open coding, axial coding, and selective coding, to identify instructional challenges and learning media needs in teaching the food chain concept. The design phase involved the creation of a storyboard and learning scenario, outlining the structure and content of the multimedia. The multimedia included text explanations, visual illustrations, instructional videos, and links to AR content embedded in a Google Sites platform. The multimedia prototype was developed using Google Sites for content delivery and Assemblr Edu to create AR-based materials.

Figure 2. Front Page Multimedia

Expert validation was conducted by subject matter experts, media experts, and educational practitioners. Validation instruments focused on content accuracy, graphic quality, and media functionality.

Table 1. Number of Trial Samples

No.	Subject	Expert Judgement	Individual	Small Group	Field Testing
1	Student V Grade	-	4	15	60
2	Teacher	2	1	1	1

3	Expert	21	-	-	-

After validation, the multimedia was piloted with fifth-grade students through three stages: individual trials, small group trials, and field testing. These implementation stages aimed to observe the practical use of the multimedia and gather feedback for improvements. The evaluation phase assessed the feasibility of the multimedia, student responses, and learning outcomes before and after using the media. Instruments included validation checklists, student response questionnaires, and pre- and post-tests on conceptual understanding. To evaluate the effectiveness of the developed multimedia compared to conventional learning methods, a quasi-experimental design was implemented using the pretest-posttest control group design. The trial was conducted in a real classroom setting involving two classes (V-A and V-B) at a public elementary school. The experimental group used the AR-integrated Google Sites multimedia, while the control group learned using standard student textbooks. The study involved two different groups experimental group: Received treatment using AR-integrated multimedia and control group: Received instruction using conventional textbook-based methods.

Table 2. Two Group Pre-test Post-test

Group	Pre-test	Treatment	Post-test
Experimental Group	O1	X	O2
Control Group	O3	-	O4

To measure the effectiveness of the multimedia, the paired sample t-test was used to compare the pre-test and post-test scores within each group, particularly to determine whether the improvement in the experimental group was statistically significant. A p-value < 0.05 indicates a significant difference in learning outcomes before and after the intervention. The independent sample t-test was applied to compare post-test scores between the experimental and control groups. A p-value < 0.05 indicates a significant difference in learning outcomes between the two groups. If both tests showed significant results, an N-Gain analysis was performed to assess the magnitude of improvement in student understanding. The interpretation of N-Gain scores is as follows High: N-Gain $\geq 0.7 \rightarrow$ Very effective, Moderate: $0.3 \leq$ N-Gain $< 0.7 \rightarrow$ Moderately effective and Low: N-Gain $< 0.3 \rightarrow$ Less effective
Additionally, effect size (Cohen's d) was calculated to measure the strength of the treatment effect between the experimental and control groups. Interpretation of Cohen's d values is small effect: $d < 0.2$, medium effect: $0.2 \leq d < 0.5$, large effect: $0.5 \leq d < 0.8$, very large effect: $d \geq 0.8$. This combination of tests provides a comprehensive analysis of both the statistical significance and practical impact of using AR-integrated multimedia in elementary science instruction.

RESULT AND DISCUSSION

This section presents the results of the study based on the four objectives: conducting a needs analysis for the development of AR-integrated multimedia, validating the developed multimedia, evaluating its effectiveness, and analyzing student responses.

These findings were obtained through trials involving fifth-grade students in two parallel classes at an elementary school, using a quasi-experimental pretest-posttest control group design. The needs analysis was carried out through interviews with students and teachers to explore the challenges they encountered in learning the food chain concept. The data were examined using content analysis techniques, including open coding, axial coding, and selective coding. The results revealed that both students and teachers had difficulty understanding the topic due to the lack of interactive and visual media. Instruction was mainly reliant on static textbook images, which were insufficient for illustrating the dynamic nature of food chain relationships. Both groups expressed the need for more engaging and contextual learning media that could offer visual representations to support conceptual understanding. These findings reinforced the necessity of developing multimedia integrated with Augmented Reality to provide more immersive and concrete learning experiences.

Figure 2. Barcode Multimedia

Following development, the multimedia was subjected to validation by content experts, media experts, and educational practitioners. The validation process assessed several aspects, including the relevance of the content, graphic presentation, and technical functionality.

Table 3. Expert Validation Results of Response Questionnaire

No	Indicator	Q	Expert			S1	S2	S3	ΣS	n(c-1)	V	Inf
			1	2	3							
1	Usage Perception	A 1	4	3	3	3	2	2	7	9	0,78	Medium
2		A 2	4	4	4	3	3	3	9	9	1,00	High
3		A 3	3	4	4	2	3	3	8	9	0,89	High
4		A 4	4	4	3	3	3	2	8	9	0,89	High
5	Perception of ease of use	B 1	4	4	4	3	3	3	9	9	1,00	High
6		B 2	4	4	3	3	3	2	8	9	0,89	High
7		B 3	3	3	4	2	2	3	7	9	0,78	Medium
8		B 4	4	3	4	3	2	3	8	9	0,89	High
9		B 5	3	4	4	2	3	3	8	9	0,89	High
10	Behavioral Intent	C 1	4	4	4	3	3	3	9	9	1,00	High
11		C 2	4	4	4	3	3	3	9	9	1,00	High
12	Attitude Towards Use	D 1	4	4	4	3	3	3	9	9	1,00	High
13		D 2	4	3	4	3	2	3	8	9	0,89	High
	Amount		49	48	49	36	35	36	Mean V		0,91	High

Table 4. Media Expert Validation Results

No	Indicator	Q	Expert			S1	S2	S3	ΣS	n(c-1)	V	Inf
			1	2	3							
1	Engineering aspects of Devices	A1	4	4	4	3	3	3	9	12	0,75	Medium
2		A2	4	5	5	3	4	4	11	12	0,92	High
3		A3	5	5	5	4	4	4	12	12	1,00	High
4		A4	4	5	5	3	4	4	11	12	0,92	High
5	Media Feasibility Aspect (Visual Communication Display)	B1	4	5	4	3	4	3	10	12	0,83	High
6		B2	5	5	3	4	4	2	10	12	0,83	High
7		B3	5	4	5	4	3	4	11	12	0,92	High
8		B4	5	5	5	4	4	4	12	12	1,00	High
9		B5	5	4	5	4	3	4	11	12	0,92	High
10		B6	4	5	5	3	4	4	11	12	0,92	High
11		B7	4	5	5	3	4	4	11	12	0,92	High
12	Media Feasibility Aspect (Software Usage)	C1	5	4	4	4	3	3	10	12	0,83	High
13		C2	5	5	4	4	4	3	11	12	0,92	High
14	Media Feasibility Aspect (Learning Media Content Substance)	D1	5	5	5	4	4	4	12	12	1,00	High
15		D2	5	5	5	4	4	4	12	12	1,00	High
16		D3	5	5	5	4	4	4	12	12	1,00	High
17		D4	5	5	5	4	4	4	12	12	1,00	High
18		D5	5	5	5	4	4	4	12	12	1,00	High
	Amount		84	86	84	66	68	66	Mean V		0,93	High

Table 5. Material Expert Validation Results

No	Indicator	Q	Expert			S1	S2	S3	ΣS	N(C-1)	V	Ket
			1	2	3							
1	Content Eligibility	A 1	4	5	5	3	4	4	11	12	0,92	High
2		A 2	4	4	5	3	3	4	10	12	0,83	High
3		A 3	4	5	5	3	4	4	11	12	0,92	High
4		A 4	5	5	5	4	4	4	12	12	1,00	High
5		A 5	5	5	4	4	4	3	11	12	0,92	High
6		A 6	5	5	4	4	4	3	11	12	0,92	High
7	Language Eligibility	B 1	5	5	5	4	4	4	12	12	1,00	High
8		B 2	5	5	5	4	4	4	12	12	1,00	High
9		B 3	5	5	4	4	4	3	11	12	0,92	High
10		B 4	4	5	5	3	4	4	11	12	0,92	High
11		B 5	4	5	5	3	4	4	11	12	0,92	High
12		B 6	5	5	5	4	4	4	12	12	1,00	High
13	Presentation	C 1	5	5	5	4	4	4	12	12	1,00	High

14		C 2	5	5	4	4	4	3	11	12	0,92	High
15	Learn to be independent	D 1	5	5	5	4	4	4	12	12	1,00	High
16		D 2	5	5	5	4	4	4	12	12	1,00	High
	Amount		75	79	76	59	63	60	Mean V		0,95	High

Table 6. Material Practitioner Validation Results

No	Indicator	Q	Expert			S1	S2	S3	ΣS	n(c-1)	V	Ket
			1	2	3							
1	Content Eligibility	A 1	5	5	5	4	4	4	12	12	1,00	High
2		A 2	5	5	5	4	4	4	12	12	1,00	High
3		A 3	5	5	5	4	4	4	12	12	1,00	High
4		A 4	5	5	5	4	4	4	12	12	1,00	High
5		A 5	5	5	4	4	4	3	11	12	0,92	High
6		A 6	5	5	5	4	4	4	12	12	1,00	High
7	Language Eligibility	B 1	5	5	5	4	4	4	12	12	1,00	High
8		B 2	5	5	4	4	4	3	11	12	0,92	High
9		B 3	5	4	5	4	3	4	11	12	0,92	High
10		B 4	5	4	4	4	3	3	10	12	0,83	High
11		B 5	5	5	5	4	4	4	12	12	1,00	High
	Amount		55	53	52	44	42	41	Mean V		0,96	High

Results of the validation, analyzed using Aiken's V index, showed that all criteria met the required validity thresholds and were categorized as feasible for use. This indicated that the multimedia fulfilled the pedagogical and technical standards necessary for its implementation in primary school learning environments, especially within the science subject matter related to ecosystems.

Table 7. Normality Test

Kelas		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Hasil	Pretes Experiment	0,144	30	0,115	0,944	30	0,119
	Postes Experiment	0,159	30	0,052	0,947	30	0,143
	Pretes Control	0,144	30	0,115	0,944	30	0,119
	Postes Control	0,156	30	0,061	0,931	30	0,053

Table 8. Independent T Test

	t-test for Equality of Means					
	t	df	Sig. (2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper

Hasil	Experiment	-12,152	58	0,000	1,865	-26,400	-18,933
	Control	-12,152	57,3	0,000	1,865	-26,401	-18,932

To examine the multimedia's impact on learning outcomes, the study employed a pretest-posttest control group design that included an experimental group using the AR-integrated multimedia and a control group using traditional student textbooks. The comparison of post-test scores between the two groups using an independent sample t-test also showed a significant difference in favor of the experimental group. These results were supported by normalized gain (N-Gain) analysis, which indicated that students in the experimental group achieved moderate to high gains in understanding, whereas the control group's improvement remained in the low category. This suggests that the AR multimedia was considerably more effective in supporting students' conceptual learning. Furthermore, the effect size analysis showed that Cohen's d exceeded 0.8, indicating a very strong influence of the multimedia intervention on learning outcomes

Aspek	Question	STS		TS		S		SS		Total	
		F	%	F	%	F	%	F	%	F	%
Usage Perception	P1	0	0	0	0	17	56,70	13	43,30	30	100
	P2	0	0	0	0	16	53,30	14	46,70	30	100
	P3	0	0	0	0	21	70,00	9	30,00	30	100
	P4	0	0	4	13,30	8	26,70	18	60,00	30	100
Perception of ease of use	P5	0	0	0	0	6	20,00	24	80,00	30	100
	P6	0	0	0	0	21	70,00	9	30,00	30	100
	P7	0	0	9	30,00	10	33,30	11	36,70	30	100
	P8	0	0	2	6,70	12	40,00	16	53,30	30	100
	P9	0	0	2	6,60	11	36,70	17	56,70	30	100
Behavioral Intent	P10	0	0	0	0	21	70,00	9	30,00	30	100
	P11	0	0	19	63,30	5	16,70	6	20,00	30	100
Attitude Towards Use	P12	0	0	3	10,00	27	90,00	0	0	30	100
	P13	0	0	8	26,70	3	10,00	19	63,30	30	100

Table 9. Respose Analysis

Tabel 10. Questionnaire Response Categorization Results

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	High	30	100,0	100,0	100,0

The final stage of the study involved evaluating student responses to the multimedia through a structured questionnaire. The results were analyzed descriptively using SPSS and focused on several indicators, including perceived usefulness, ease of use, behavioral intention, and attitudes toward the learning media. The analysis revealed that all students

gave positive responses. Most of them found the multimedia enjoyable, easy to navigate, visually appealing, and helpful in understanding the food chain material. These responses indicated a high level of student satisfaction and acceptance, confirming that the AR-integrated multimedia developed using Google Sites was both practical and user-friendly in the context of classroom learning.These findings are consistent with previous research, such as the study conducted by (Mukti, 2019), which reported that AR-based learning media could effectively bridge abstract science concepts with real-world experiences. The integration of Augmented Reality into a web-based platform in this study contributed to independent, interactive, and immersive learning experiences, effectively addressing the initial instructional challenges faced by students and teachers. The combination of statistical evidence and strong student engagement supports the conclusion that AR-integrated multimedia serves as a powerful and effective tool to improve conceptual understanding in elementary science education.

CONCLUSION

This study concludes that the development of AR-integrated multimedia through Google Sites effectively enhances elementary students' understanding of the food chain concept. The multimedia addressed existing learning challenges by providing engaging, interactive, and visual content, which was previously lacking in traditional textbook-based instruction. Expert validation confirmed that the content was pedagogically sound and technically feasible for classroom use. Statistical testing demonstrated that students in the experimental group showed significantly higher learning gains compared to those in the control group. These results were further supported by positive student feedback, which highlighted the usefulness, ease of access, and overall engagement provided by the multimedia. The integration of Augmented Reality and web-based platforms has the potential to transform science instruction in primary education. By enabling flexible, immersive, and student-centered learning, such multimedia tools can serve as valuable resources for curriculum implementation. Future research is encouraged to apply this model across different subjects and educational contexts to explore broader impacts.

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