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The Effectiveness of Augmented Reality-Based Sispen Media in Improving the Understanding of The Digestive System Concept of Elementary School Students

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ABSTRACT

This study aimed to examine the effectiveness of SISPEN (Digestive System) learning media based on Augmented Reality (AR) in improving elementary school students' conceptual understanding of the human digestive system. The increasing demand for innovative digital learning media in the 21st century, particularly for abstract science topics, underscores the urgency of developing interactive and immersive learning tools. This research employed a quantitative approach using a pre-experimental design with a one-group pretest–posttest design. A total of 24 fifth-grade students aged 10–11 years from SDN Majalengka Wetan VII participated in this study and were selected using purposive sampling. Data were collected through conceptual understanding tests (pretest and posttest), student motivation questionnaires, and classroom observation sheets. The results showed a significant increase in students' average scores from 52.33 (pretest) to 77.62 (posttest). The N-gain value of 0.54 indicated a moderate level of effectiveness, with 63% of students categorized in the moderate gain category and 21% in the high gain category. The paired-sample t-test confirmed a statistically significant difference between pretest and posttest scores ($t = 38.77$, $p < 0.05$). In addition, students demonstrated a very positive response toward the AR-based media, with an average motivation score of 3.49 (very good category). These findings suggest that SISPEN AR-based learning media effectively enhances both cognitive understanding and learning motivation among elementary school students. This study contributes to the development of AR-based digital learning media aligned with constructivist pedagogy and the TPACK framework in Indonesian primary education contexts.

INTRODUCTION

The development of digital technology over the past decade has brought significant transformations across various sectors, including basic education (Nisa et al., 2025; Oliveira & Souza, 2021). The integration of technologies such as Augmented Reality (AR) in learning has gained increasing attention due to its potential to create interactive and immersive learning experiences (Kazlaris et al., 2025; Shofiyuddin et al., 2025; Anwar, 2025). The UNESCO report (2023) confirms that the digital transformation of education is a global priority agenda aimed at improving the quality of 21st-century learning (Zou et al., 2025). In Indonesia, the Merdeka Learning policy also encourages the use of digital technology to enhance student engagement and understanding (Haq et al., 2024; Suci et al., 2025). However, the

implementation of innovative technology at the elementary school level still faces various limitations, particularly in providing contextual, validated, and developmentally appropriate learning media aligned with students' cognitive development (Nurrizka et al., 2025; Rosbina et al., 2025).

In the context of Natural Science (IPA) learning in elementary schools, the human digestive system is considered an abstract topic because it involves internal biological processes that cannot be directly observed (Ruswati et al., 2025). Recent studies show that elementary school students often experience misconceptions about body organ systems due to the dominance of lecture-based methods and the use of two-dimensional media (Rahmawati & Prasetyo, 2022; Liu et al., 2024). Limited visualization leads to low conceptual understanding and decreased student learning motivation (Azizah et al., 2022; Khaira et al., 2025; Saputri & Lisdiana, 2025). This condition indicates an urgent need for learning media capable of concretizing abstract concepts through interactive visual representations.

Along with technological developments, AR is considered one of the potential solutions for improving the quality of science learning (García & Fernández, 2025; Mansour et al., 2024; Kuanbayeva et al., 2024; Hidayati et al., 2025). Recent studies (Santos et al., 2023; Kim & Park, 2024) show that AR can enhance conceptual understanding, knowledge retention, and learning motivation through the integration of three-dimensional virtual objects into real-world environments (Lin & Yu, 2023; Son et al., 2025; Dewi, 2025). In biology and basic science learning, AR enables students to visualize organ structures and physiological processes more realistically and dynamically than conventional media (Abhyankar et al., 2025) and (Evangelista, 2024). Therefore, AR is theoretically aligned with constructivist approaches that emphasize experiential learning (Afnan & Puspitawati, 2024; Garg et al., 2025).

However, the implementation of AR in elementary schools remains limited to the development of generic applications without a comprehensive needs analysis stage (Koumpouros, 2024). Several studies in Indonesia (e.g., Hidayat et al., 2023; Wulandari & Sari, 2024) have focused on testing the effectiveness of AR media but have not fully explored user-centered design processes. In fact, needs analysis is a crucial stage in development research to ensure alignment between products, student characteristics, basic competencies, and classroom learning contexts.

In terms of the state of the art, AR research trends from 2022–2026 show a shift from merely testing effectiveness toward learner experience design and strengthening intrinsic motivation (Chen et al., 2025). This approach emphasizes the integration of pedagogical, technological, and content knowledge (TPACK) in digital media development (Belda & Calvo, 2022). However, studies that specifically integrate needs analysis, media design, and the improvement of conceptual understanding of the digestive system at the elementary level remain limited, particularly in the Indonesian context.

Based on the literature review, a significant research gap can be identified. First, few studies have systematically documented needs analysis as the basis for designing AR media for Grade V elementary school digestive system materials. Second, most studies focus on final outcomes (effectiveness) without explaining the rationale behind product design or its relationship to learning motivation and conceptual understanding. Third, there is still a lack of studies developing AR media based on the national curriculum context and the characteristics of Indonesian elementary school students.

The urgency of this research is increasingly relevant given the demands of 21st-century learning, which emphasize digital literacy, critical thinking, and deep conceptual understanding (Jordan et al., 2025; Zebua, 2025). Without innovative, needs-based media support, science learning risks remaining overly textual and less meaningful. Therefore, needs analysis and AR-based media design represent a strategic step to address these challenges while supporting the digital transformation of basic education.

The novelty of this research lies in the integration of comprehensive needs analysis with the design of AR-based SISPEN (Digestive System) media, aimed at improving conceptual understanding and learning motivation among elementary school students. This study not only develops a product but also formulates design specifications based on empirical needs from teachers and students, integrating constructivist pedagogy principles and the TPACK framework. Thus, the contribution of this research is both conceptual and practical in the development of digital learning media at the elementary education level.

Based on this presentation, this research is focused on analyzing the needs and designing the design of Augmented Reality-based SISPEN learning media to improve the understanding of the concept of the digestive system of elementary school students. In particular, this research aims to identify the needs of users as the basis for development and formulate relevant, contextual, and pedagogical media designs. The next section will explain the formulation of the problem and the objectives of the research in more detail. The expected benefits of this research are to make a theoretical contribution to the development of educational technology and science pedagogy through the application of Augmented Reality and the enrichment of the TPACK framework in the context of basic education in Indonesia, becoming a practical reference for teachers and practitioners in developing AR-based learning media that suit the needs of students, providing direct experience for researchers in the process of analyzing needs, design design, and testing of the effectiveness of AR media, are considerations for policymakers in formulating pedagogical and contextual digital technology integration strategies, as well as contributing to the development of digital learning media that can be accessed and utilized by other schools in Indonesia, especially for abstract science materials that require interactive visualization.

METHOD

Research Type and Design

This study employed a quantitative approach using a pre-experimental design, specifically a one-group pretest–posttest design. The design was used to examine the effect of Augmented Reality-based SISPEN learning media on elementary school students' understanding of the digestive system concept.

The research design is described as follows:

O_1 — X — O_2

Description:

O_1 = Pretest (initial test of concept understanding)

X = Treatment (learning using AR-based SISPEN media)

O_2 = Posttest (final test of concept understanding)

Through this design, the improvement of students' concept understanding was measured by comparing pretest and posttest scores after being given treatment.

Research Participants

The study participants were 24 grade V students at SDN Majalengka Wetan VII aged 10–11 years. Students are at the stage of concrete operational development, so the use of interactive visual media such as Augmented Reality is considered appropriate to help understand abstract concepts of the human digestive system.

The sample selection technique uses purposive sampling, with the following considerations:

1. Students have studied the material on the digestive system according to the curriculum.
2. The school has supporting facilities for the use of digital devices.
3. Teachers are willing to cooperate in the implementation of experiments.

All students in one class are used as an experimental group.

Data Collection Techniques

The data in this study was collected using the following instruments:

a. Concept Comprehension Test

The test is in the form of multiple choice and/or a brief description given before (pretest) and after treatment (posttest). The questions are prepared based on indicators of concept understanding and have gone through the content validity test by subject matter experts.

b. Student Response Questionnaire

The questionnaire used a 4-level Likert scale to determine students' responses to the use of AR-based SISPEN media, including aspects of interest, ease of use, and learning motivation.

c. Documentation

Documentation is carried out to collect supporting data in the form of a list of grades, photos of learning activities, and learning tools used.

Data Analysis Techniques

Data analysis was carried out quantitatively with the following stages:

a. Descriptive Statistical Analysis

Used to calculate average values, standard deviations, maximum and minimum values.

b. Normality Test

It was done to find out if the data was normally distributed (using the Shapiro-Wilk test because the sample count was < 50).

c. Hypothesis Test

To determine the effect of the use of AR-based SISPEN media on students' concept understanding, a paired t-test (Paired Sample t-test) was used.

d. N-Gain Calculation

To determine the degree of improvement in understanding of concepts, the N-Gain formula is used:

N-Gain=Sko

$$N\text{-}Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maksimum - Skor\ Pretest}$$

Interpretation criteria:

$g \geq 0.70$ = High

$0.30 \leq g < 0.70$ = Medium

$g < 0.30$ = Low

RESULT AND DISCUSSION

This study involved 24 elementary school grade V students at SDN Majalengka Wetan VII who participated in learning using Augmented Reality (AR)-based SISPEN learning media on human digestive system materials. Data were obtained through concept comprehension tests (pretest–posttest), learning response/motivation questionnaires, and learning implementation observation sheets.

a. Improving Understanding of the Digestive System Concept

The results of descriptive statistical analysis showed a clear increase between pretest and posttest scores. The average student pretest score of 52.33 increased to 77.62 in the posttest. The standard deviation of the pretest is 4.36, while the standard deviation of the posttest is 5.52. This improvement shows that after the use of AR-based SISPEN media, students' concept understanding undergoes significant changes and is relatively even.

Table 1. Descriptive Statistics

Statistics	Pretest	Posttest
Number of Students	24	24

Average	52,33	77,62
Standard Deviation	4,36	5,52

Based on the table, there was a significant increase in the average score after the treatment was given. This shows that AR media contributes to improving student learning outcomes.

N-Gain calculation

The N-Gain calculation was carried out to determine the level of effectiveness of increasing students' understanding of concepts.

N-Gain Formula:

$$N\text{-}Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maksimum - Skor\ Pretest}$$

The results of the analysis showed an average N-Gain of 0.54 which was in the medium category ($0.3 \leq g \leq 0.7$).

Table 2. Upgrade Categories

Categories	**Number of Students**	**Introduce yourself**
Height (g>0.7)	5	21%
Medium (0.3-0.7)	15	63%
Low (g**<0.3)**	4	16%

Most students (63%) experienced improvements in the medium category, and 21% were in the high category. This data shows that the use of AR-based SISPEN media is effective in improving understanding of the concept of the digestive system.

Paired Sample t-test

The results of the normality test showed normal distribution data (Sig > 0.05), so the Paired Sample t-test was used. The test results showed a calculated t-value = 38.77 and a significance value (2-tailed) < 0.05. This means that there is a significant difference between pretest and posttest scores. Thus, the use of Augmented Reality-based SISPEN learning media has a significant effect on improving the understanding of the concept of the digestive system of grade V students at SDN Majalengka Wetan VII.

Improvement Based on Concept Understanding Indicators

When analyzed by indicator, the highest improvement occurred in the ability to identify the organs of the digestive system and explain the relationship between the structure and function of the organs. Before treatment, students tend to only memorize the names of organs without understanding the process and its relationships.

After using AR media, students can observe a three-dimensional model of the digestive organs, rotate objects, and see the digestive process visually and interactively. This helps students build more concrete and systematic mental representations.

Student Learning Response and Motivation

The results of the questionnaire showed that students responded very positively to the use of AR-based SISPEN media. The average motivation score is in the very good category.

Table 3. Student Learning Response/Motivation

Aspects	Average Score	Categories
Interest	3,56	Excellent
Clarity of Material	3,42	Good
Confidence	3,38	Good
Learning Satisfaction	3,61	Excellent
Total Average	3,49	Excellent

More than 75% of students agreed and strongly agreed that AR media helps them understand the digestive system better. This shows that there is a positive impact not only on the cognitive aspect, but also on the affective aspect of the student.

Observation of Learning Implementation

The results of the observation showed that all stages of learning were carried out as planned. Students actively explore 3D objects, discuss, and show high enthusiasm during the learning process. Teachers are also able to facilitate the effective use of AR media.

A significant increase in understanding of digestive system concepts shows that the integration of Augmented Reality in science learning makes a real cognitive contribution. The increase in the average score from 52.33 to 77.62 indicates that three-dimensional visualization helps students understand previously abstract concepts.

The N-Gain value of 0.54 which is in the medium category shows that AR media is quite effective in improving learning outcomes. The most significant improvement occurred in indicators of the relationship between structure and organ function, which were previously difficult to understand through two-dimensional images.

From the affective side, the response of students who are in the category of being very good shows that AR-based learning is able to increase learning engagement and motivation. Interactive visualizations provide a more concrete and enjoyable learning experience.

However, the effectiveness of AR is still influenced by other factors such as technology readiness, teachers' ability to manage digital learning, and the duration of media use. Therefore, AR integration needs to be designed systematically and pedagogically.

Overall, the results of this study show that Augmented Reality-based SISPEN learning media is effective in improving the understanding of the concept of the digestive system of elementary school students, both from cognitive and affective aspects.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the use of Augmented Reality-based SISPEN learning media has a positive and significant influence on improving the understanding of the concept of the digestive system in grade V students of SDN Majalengka Wetan VII. This is shown by the increase in the average pretest score to the posttest as well as the results of statistical tests that show a significant difference ($p < 0.05$). The N-Gain value in the medium category indicates that AR media is able to substantially improve students' conceptual understanding, especially in the indicators of visual representation and understanding of interorgan relationships in the digestive system. The integration of interactive 3D objects helps students build more concrete mental representations of abstract concepts.

In addition to the cognitive aspect, AR-based SISPEN media also contributes to increasing student learning motivation, especially in the aspect of attention and learning satisfaction. This shows that the use of technology that is pedagogically designed is able to increase student involvement in the learning process. Overall, this study confirms that the design of Augmented Reality-based learning media that is systematic and according to the needs of students can be an effective innovation in science learning in elementary schools.

These findings imply that AR integration needs to be accompanied by careful pedagogical planning in order to have an optimal impact on student learning outcomes.

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