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Improving visual-spatial ability through anatomy apron in respiratory system learning

Tasya Khaeratunnisa*, Arda, Siti Rabiatul Adawiyah

Department of Science Education, Faculty of Tarbiyah and Teacher Training, State Islamic University Datokarama Palu, Indonesia

* Corresponding author: tasyakhaeratunnisa411@gmail.com

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ABSTRACT

This study was undertaken to address the ongoing challenges students encounter in comprehending abstract anatomical ideas, especially those necessitating robust visual-spatial abilities, attributed to the inadequate utilization of tangible learning resources in science classes. This study investigates the impact of anatomical teaching aids on the visual-spatial abilities of eighth-grade students studying the human respiratory system at MTs Negeri 3 Palu. A quasi-experimental approach utilizing a pretest-posttest control group was implemented. The sample comprised 36 students, allocated into an experimental group of 18 students and a control group of 18 students. The experimental group utilized an anatomical apron as a teaching tool, whereas the control group was instructed by conventional memorizing techniques. A validated 15-item assessment was employed to evaluate pupils' visual-spatial abilities. Data were investigated utilizing N-Gain computations and an independent samples t-test subsequent to the fulfillment of normality and homogeneity assumptions. The findings indicated that the experimental group's average N-Gain score was classified as high and surpassed that of the control group. The t-test analysis produced a significance (2-tailed) value of 0.000 (< 0.05), signifying the rejection of H_0. The findings indicate that anatomical apron teaching aids enhance students' visual-spatial abilities in the study of the human respiratory system.

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INTRODUCTION

Science education is central in developing scientific thoughts of students, especially in comprehending natural phenomena, biological processes that happen in our daily lives

(Fadillah & Adlini, 2025; Fauziah et al., 2024; Lubis et al., 2025). Science learning does not only emphasize mastery of factual concepts but also focuses on students' ability to construct mental representations of the objects and processes being studied (Rahman et al., 2021) . The processes of visualization and spatial understanding are crucial components to ensure that scientific concepts are meaningfully understood rather than merely memorized (Analicia & Yogica, 2021).

The human respiratory system topic at the Madrasah Tsanawiyah level is widely recognized as one of the most challenging science topics due to its abstract nature. Previous classroom observations and research indicate that students often experience difficulties in understanding the structure, function, and spatial relationships of respiratory organs because these internal organs cannot be directly observed during learning activities. As a result, students tend to rely on rote memorization rather than conceptual understanding, which leads to low visual-spatial ability and misconceptions regarding the respiratory process. This topic covers the structure and function of internal organs that require students to imagine the shape, position, and interrelationships of organs within an integrated system (Dewi & Setyasto, 2024). Classroom practices are still largely dominated by lecture methods and the use of two-dimensional media, such as static images or presentation slides, which do not fully support students in constructing a comprehensive visual representation of the human respiratory system (Situmorang et al., 2025).

Students' spatial visualization abilities closely relate to their difficulties in understanding the human respiratory system. Spatial visualization ability is defined as an individual's capacity to visualize, manipulate, and comprehend the relationships between objects in space (Pranova et al., 2025). In science learning, particularly in human anatomy topics, this ability plays a crucial role because students are required to understand the three-dimensional structure of organs as well as the functional relationships between their parts (Jannah et al., 2025). Students with low spatial visualization skills tend to face obstacles in grasping complex anatomical concepts, even after receiving verbal explanations (Harefa & Gulo, 2024).

Teachers' teaching strategies and learning media greatly influence the development of students' spatial visualization skills. Concrete learning media that provide direct visual representations can help students build a better spatial understanding (Zulia & Alimah, 2023). The anatomical apron model is a useful learning tool for this process. This media presents a systematic and concrete visualization of human organs, enabling students to observe organ structures and understand the interrelationships among organs within the respiratory system more tangibly (Nuryani & Abadi, 2021).

Some of the past researchers have indicated that science education teaching aids can enhance student learning, interest, and engagement. Teaching aids are also thought to be useful for helping students understand abstract concepts by giving them more concrete learning experiences (Tegeh et al., 2020; Waruwu et al., 2024). Nonetheless, the predominant emphasis of these studies has been on assessing general cognitive learning outcomes, such as concept mastery or test scores, whereas research investigating spatial visualization ability as a primary variable is still relatively scarce.

The lack of empirical studies is also evident in research specifically examining the use of anatomical apron models in science education. There is limited research on how this media has been used to deliver the spatial visualization abilities of students in the human respiratory system, especially at the Madrasah Tsanawiyah. This situation indicates a research gap that needs to be further explored to strengthen the empirical evidence regarding the effectiveness of anatomical apron models in enhancing students' spatial visualization abilities.

The study aims to take into account the effects of the introduction of anatomical apron models on the spatial visualization ability of the eighth-grade students who were instructed on the subject of the human respiratory system within the Mts Negeri 3 Kota Palu area. Hopefully, the results of this research will provide terms of contribution to the theoretical knowledge in the education of science learning based on space, as well as in practical terms, so that the teachers can make the appropriate choice of learning media.

RESEARCH METHODS

Research Design

The current research used quantitative methodology using a quasi-experimental research design, which involved a pretest-posttest design that was a control group research design. The design chosen to examine the effects of anatomical apron teaching aids on the visual-spatial abilities of the students by comparing the results of the experimental and the control group prior to the intervention and after it.

Table 1. Pretest-posttest control group design

Group	Pretest	Treatment	Posttest
Experimental	O_1	X (Anatomical apron teaching aid)	O_2
Control	O_3	– (Conventional learning method)	O_4

Notes:

O_1 : Pretest of the experimental group

O_2 : Posttest of the experimental group

O_3 : Pretest of the control group

O_4 : Posttest of the control group

X : Treatment using the anatomical apron teaching aid

– : No treatment (conventional learning)

Population and Samples

The population of the study was made up of all the eighth-grade students at MTs Negeri 3 Palu. There were 36 students who participated in the sample through purposive sampling. Their presence was due to the selection of the classes having the same level of academic skills, as well as being taught the same material on the human respiratory system. The sample was divided into two; the experimental sample comprised 18 students of Class VIII A, whereas the control sample comprised 18 students of Class VIII B.

Instruments

The test of this experiment was a visual-spatial ability test consisting of 15 questions that had multiple choices. Markers of visual-spatial aptitude were used to make the exam, including the ability to visualize the arrangement of organs in space, the ability to understand the relationship between organs in space, and the ability to read a diagram of the respiratory system. Before being used, the instrument was tested for content validity by experts to make sure that the test items were suitable for measuring students' visual-spatial ability. In addition, empirical validation was conducted through a pilot test to determine the validity and reliability values of each item. Item validity was measured using the Pearson product-moment correlation coefficient, while instrument reliability was calculated using Cronbach's Alpha coefficient, ensuring that the test consistently and accurately measured students' visual-spatial ability.

Procedures

The research process had some different steps. The initial measure involved pre-testing both the experimental and the control group to determine the visual-spatial abilities that they had before. The next step was to put the lessons into action. The experimental group learned science with the help of anatomical apron teaching aids, whereas the control group learned more traditionally without any anatomical apron media. After the lessons were over, both groups took a posttest to see how well the kids could see and move around after the treatment.

Data Analysis

The data that were collected were looked at in a quantitative way. Normality and homogeneity tests were among the tests that had to be passed before. We used normalized gain (N-Gain) to look at how much better students' visual-spatial skills got (Apriliani & Herlanti, 2025) (Table 2). It also involved an independent samples t-test, which was performed to check whether the experimental and the control group had any differences at the level of 0.05.

Table 2. Gain value category

N-Gain	Category
$(g) \geq 0.7$	High
$0.3 < (g) < 0.7$	Medium
$(g) < 0.3$	Low

RESULTS

Figure 1 illustrates the result of the descriptive statistics analysis of the pretest and post-test scores of visual-spatial ability of the students in the experimental and the control group. The average pretest scores in the two groups were not very different, implying that, at the first stage, abilities were the same. Following the treatment, the experimental group was found to experience more improvement in the mean posttest score as compared to the control group.

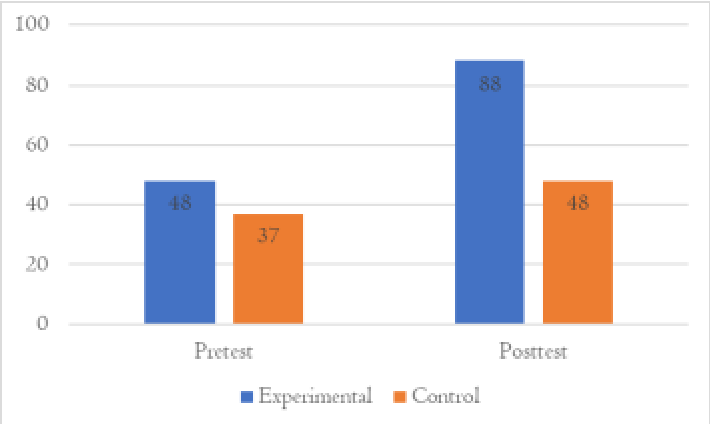

Figure 1. Mean Pretest and Posttest Scores

In order to analyze the enhancement further, the visual-spatial ability of the students was assessed through normalized gain (N-Gain). As can be seen in Table 3, the experimental group got an N-Gain score of 0.73, which is classified as high; the control group got an N-Gain score of 0.17, which is classified as low. The result of this discovery shows that using the anatomy apron teaching aid led to a higher increase in the visual-spatial ability of the students as compared with the traditional teaching method.

Table 3. Results of the n-gain analysis of students' visual-spatial ability

Group	N-Gain	Category
Experimental	0.73	High
Control	0.17	Low

The data were studied to test the normality and homogeneity so that the assumptions of parametric analysis would be fulfilled before hypothesis testing. The results of the normality test presented in Table 4 show that the value of the Shapiro-Wilk test greater than 0.05 is an indication that the data were normally distributed and had equal variances.

Table 4. Normality test of students' visual-spatial ability

Tests of Normality							
Group		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Score	Experimental	0.200	18	0.055	0.909	18	0.083
	Control	0.187	18	0.097	0.904	18	0.067
a. Lilliefors Significance Correction							

Hypothesis testing was undertaken based on an independent samples t-test, as the conditions of the prerequisites were met. The findings in Table 5 show that the Sig. (2-tailed) The value was less than the level of significance of 0.05. This finding validates that the visual-spatial ability of students in the experimental group and control group had a significant difference. Therefore, the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_a) was accepted.

Table 5. Results of the independent samples t-test on students' visual-spatial ability

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score	Equal variances assumed	0.348	0.559	12.026	34	0.000	38.111	3.169	31.671	44.551
	Equal variances not assumed			12.026	33.877	0.000	38.111	3.169	31.670	44.552

DISCUSSION

This study's findings indicate that the use of the anatomy apron teaching aid significantly enhanced students' visual-spatial abilities related to the human respiratory system. The N-Gain analysis indicates that the experimental group achieved a score of 0.73, classified as high, whereas the control group attained a score of 0.17, classified as low. This significant disparity suggests that the enhancement in visual-spatial ability in the experimental group was markedly superior to that of the control group. The elevated N-Gain score in the experimental group indicates the effectiveness of the anatomy apron teaching aid in promoting significant learning experiences that enhanced students' spatial comprehension of respiratory organ parts. The low N-Gain score in the control group indicates that, in the absence of concrete and visual learning resources, students had restricted possibilities to develop a thorough spatial understanding of the organs associated with the human respiratory system. The independent samples t-test produced a t-value of 12.026 and a two-tailed significance (Sig.) value of 0.000, significantly lower than the 0.05 threshold, leading to the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_a). The experimental group exhibited a mean difference of 38.111 in visual-spatial ability, with a 95% confidence interval of 31.671 to 44.551, indicating sustained superiority over the control group. The results demonstrate that utilizing the anatomy apron teaching aid significantly outperformed traditional learning methods in improving students' visual-spatial abilities.

The instructional resource employed in the experimental group to enhance visual-spatial ability is tangible, visual, and contextual, elucidating the advancement of this skill. This educational medium enables students to directly observe the position, morphology, and spatial relationships of the organs inside the human respiratory system, offering a concrete and immediate visual reference that is typically inaccessible in traditional classroom environments. This facilitates the formation of more distinct mental representations of inherently abstract biological structures, since students are no longer compelled to depend exclusively on their imagination to comprehend the arrangement and interconnection of organs such as the trachea, bronchi, lungs, and diaphragm within the body. Consequently, students' comprehension improves. This discovery aligns with visual-spatial learning theory, which posits that spatial aptitude is enhanced when pupils engage actively with three-dimensional or semi-three-dimensional visual media. The anatomy apron, by displaying organ structures in a wearable and spatially precise manner, immediately enhances students' spatial cognition and allows for a more active and meaningful engagement with anatomical knowledge.

Conversely, traditional learning employed in the control group predominantly depended on verbal elucidations and two-dimensional resources, such as textbooks or static visuals. This method offered a restricted visual experience for students to comprehend the spatial relationships among organs, as two-dimensional representations inherently do not convey depth, location, and the three-dimensional organization of interior body structures. Consequently, pupils in the control group exhibited a greater propensity for rote memorizing instead of cultivating an authentic spatial comprehension of the respiratory system, leading to a comparatively diminished enhancement in visual-spatial ability. This condition elucidates why the N-Gain score of the control group was classified as low in comparison to the experimental group, underscoring the inherent restriction of two-dimensional instructional media in fostering visual-spatial skills in anatomy-related subjects.

This discovery suggests that the anatomy apron teaching aid functions as a conduit between abstract concepts and students' tangible learning experiences. In science education, particularly in biology, many topics require the ability to visualize the organization and positioning of organs within the human body. The human respiratory system poses a considerable challenge for students due to its internal structures, which are not directly observable during standard learning activities, hindering the formation of accurate spatial representations without adequate instructional support. When pupils depend exclusively on imagination without the aid of tangible media, the process of knowledge production is suboptimal (Sholahudin et al., 2025). The anatomy apron facilitates the systematic enhancement of pupils' visual-spatial abilities by offering a tangible, worn representation that appropriately depicts the spatial configuration of respiratory organs. This finding aligns with a meta-analysis demonstrating that three-dimensional visualization media enhance comprehension of spatial relationships in anatomy education (Wang et al., 2024), thereby reinforcing the theoretical justification for utilizing the anatomy apron as an instructional resource in science education.

The outcomes of this study corroborate other research, demonstrating that the utilization of visual and manipulative learning media enhances students' visual-spatial skills and comprehension of scientific topics. It was indicated that 3D augmented reality learning media markedly improved students' visual-spatial intelligence in biology, aligning with the current study's conclusion that three-dimensional concrete media yielded substantial advancements in visual-spatial capability (Triyanto et al., 2025). It was also proved that augmented reality-integrated e-modules effectively enhanced students' visual-spatial intelligence, demonstrating the superiority of visual and manipulative media over traditional instruction in cultivating this skill (Zulaika et al., 2025).

Despite the differing media types, with the current study utilizing a physical teaching aid and previous studies employing digital technology, both methodologies adhere to the fundamental principle of offering student's tangible, spatially enriched representations that facilitate the development of visual-spatial comprehension. The convergence of findings from various visual media reinforces the assertion that the primary factor influencing enhancement in visual-spatial ability is not the specific media format, but its ability to convey spatial information in a tangible, accessible, and interactive way. Interactive learning media enhance student engagement and mitigate misconceptions about the structure and function of human body organs (Mahayani et al., 2025; Thomas et al., 2026), a benefit also demonstrated in the current study through the significant improvements noted in the experimental group. Consequently, the anatomy apron teaching aid can function as an excellent alternative educational resource for science instruction at the junior secondary school level (SMP/MTs), especially for subjects necessitating pupils to cultivate a robust spatial comprehension of biological structures.

This study's results emphasize that the choice of suitable learning media is crucial for improving the quality of science instruction, particularly in fostering students' visual-spatial abilities. The anatomy apron teaching aid facilitates the attainment of learning objectives while offering students more substantive learning experiences by converting abstract anatomical concepts into visible and concrete representations. The findings indicate that junior secondary science teachers should incorporate tangible, three-dimensional teaching aids into their instructional methods, especially when addressing topics with intricate spatial relationships among biological structures.

CONCLUSION

According to the results and discussion, it is possible to state that using the anatomy apron teaching aid positively influences the visual-spatial ability of the students in the topic of the human respiratory system. The students who underwent the anatomy apron learning experience showed a higher increase in the visual spatial ability than students who received the standard teaching, as shown by the N-Gain score of 0.73, which was categorized as high. The experimental group had a better N-Gain score of 0.73 than the control group score of 0.17. The statistical results of the test also indicated that there was a great difference between the two groups, as indicated by the Sig. (2-tailed) value of 0.000 (< 0.05). Thus, the teaching aid of an anatomy apron may be regarded as an effective alternative learning medium that may be implemented in teaching science, especially in the sciences involving visualization skills and spatial relations between structures of the organs.

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