Game-Based Learning Implementation in Respiratory System Topics to Improve Students' Understanding of Lung Volume and Capacity

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Abstract. Biology is a subject closely related to everyday life because one of its topics is humans. However, most of the learning objects cannot be observed with the naked eye, for example, in the respiratory system. Real-life illustrations and examples are needed to demonstrate the respiratory process. One learning medium that can be used is a balloon and cotton swab used to practice lung volume and capacity implemented through game-based learning. Therefore, this study was conducted with the aim of explaining the learning process in the respiratory system material, specifically related to lung volume and capacity, implemented through game-based learning. This study used a qualitative descriptive method. Data were obtained through interviews with teachers and students, observations of learning implementation, and a learning achievement questionnaire. The results showed that this learning was carried out by applying the syntax of the game-based learning model, namely motivation and orientation, exploration and implementation, collaboration and discussion, and reflection and elaboration of concepts by using balloons and cotton swabs as teaching aids. This learning received a positive response from students, as indicated by their understanding of the material and their enthusiasm in participating in the learning process. The results of the final evaluation showed that the average student mastery of the learning material was 89%.

Keywords: Game-Based Learning, Respiratory System Topics, Lung Volume and Capacity

INTRODUCTION

Education plays a crucial role in supporting the development of individual abilities, including knowledge, attitudes, and skills. The learning process in schools demands a design that is not only oriented toward academic achievement but also relevant to the characteristics of today's students (Mifrokhatul et al., 2025) . The Independent Curriculum implemented in Indonesia is designed to address these needs through flexible, student-centered learning that encourages active engagement. This approach emphasizes learning differentiation to meet diverse learning needs so that students can develop according to their individual potential and learning styles (Kinanthi et al., 2025) .

Generational changes also influence students' learning patterns. Generation Z grew up in a fast-paced and digital environment, thus expecting interactive, meaningful, and non-monotonous learning (Silalahi et al., 2025) . This situation encourages teachers to present learning models that can increase motivation, create a pleasant learning atmosphere, and still meet the expected competency achievements. One approach that is widely used and in line with the characteristics of today's students is game-based learning (Araina et al., 2025) . This approach combines game activities with learning concepts so that students can engage through direct experience, collaborate, and practice critical thinking in solving problems during the game (Abidin et al., 2020) .

Game-based learning not only creates a fun learning environment but also allows students to explore and build understanding independently. By combining elements of competition, challenges, and hands-on practice, this approach can help students accustomed to instant information consumption become more adept at learning processes that require persistence and reflection. Furthermore, the use of games allows teachers to convey abstract concepts through concrete media accessible to students' everyday experiences (Moradian & Nazdik, 2019; Musyaffi et al., 2022) .

Biology, as a subject that studies living things and life processes, often requires the use of aids to visualize concepts that cannot be directly observed (Kusnoto, 2019; Sari et al., 2023) . One topic that requires a contextual approach is the respiratory system, specifically the topic of lung volume and capacity. Understanding this concept requires concrete experiences so students can connect theoretical knowledge with real-world conditions. Simple tools such as balloons and cotton can be used to help students visualize differences in air volume in the lungs and the mechanics of breathing through play activities (Kale et al., 2021; Rahmadani et al., 2023).

The integration of game-based learning into the respiratory system provides students with opportunities to understand concepts through practical experiences. Game activities allow students to observe, measure, and compare the volume of air produced under different conditions, making the learning process more meaningful. Furthermore, the competitive and collaborative atmosphere of the game can increase student enthusiasm and encourage active participation throughout the learning process. (Dewi et al., 2025; Putri et al., 2025) .

Based on the urgent need for contextual and interactive learning, this study was conducted to explain the implementation of game-based learning on the topic of the respiratory system, particularly regarding lung volume and capacity, and to analyze students' understanding after participating in the learning.

MATERIALS AND METHODS

Types of research

This study used a qualitative descriptive approach aimed at providing an in-depth description of the game-based learning process on the respiratory system, specifically lung volume and capacity. This approach was chosen because the research focused on understanding naturalistic learning phenomena in the classroom and emphasized the process, context, and student learning experiences. The study was conducted in a junior high school class implementing the Independent Curriculum (Creswell, 2014) .

Research Subjects

The research subjects consisted of a biology teacher and eighth-grade students participating in a lesson on the respiratory system. The teacher was selected as an informant to explain the planning and implementation of the lesson, while the students were selected to describe their involvement, learning experiences, and understanding of the concepts of lung volume and capacity. Subject selection used a purposive sampling technique, adjusting the need for information relevant to the research focus (Lodico et al., 2010) .

Research Procedures

The research was conducted through several stages, including planning, implementation, and evaluation. In the planning stage, the researcher coordinated with the teacher to understand the learning objectives, teaching materials, and the syntax design of the game-based learning. The implementation stage involved direct observation of the learning process, which included orientation, exploration and implementation of the game, collaboration and discussion, and reflection. During the learning activities, the teacher utilized props such as balloons and cotton as exploratory media in the game to illustrate the concepts of lung volume and capacity. In the evaluation stage, the researcher collected data on student understanding through a learning achievement questionnaire and observation notes (Sugiyono, 2023) .

Data collection technique

Research data was collected through three techniques: interviews, observations, and questionnaires. Interviews were conducted with teachers and several students to obtain information about learning experiences, student perceptions, and the effectiveness of game use. Observations were used to observe student engagement during the game, how teachers implemented game-based learning syntax, and interactions that occurred throughout the lesson. A questionnaire was used to determine students' level of understanding of the material after participating in the game (Sugiyono, 2023) .

Data analysis

Data analysis was conducted using an interactive model that includes data reduction, data presentation, and conclusion drawing. All data from observations, interviews, and questionnaires were reduced to identify findings relevant to the research focus. The data were then presented in descriptive form to illustrate the learning process and student responses. The final stage, drawing conclusions, was carried out continuously until valid results were obtained that reflected the learning reality (Huberman & Miles, 1984) .

RESULTS AND DISCUSSION

Game-based learning on the respiratory system was conducted in a single session, utilizing balloons and cotton balls. The learning process followed a game-based learning syntax consisting of four main stages. Data were obtained through observations of student activities, interviews with teachers and several students, and questionnaires assessing understanding of the material. The learning process utilized a game-based learning syntax, which can be detailed as follows:

1. Motivation and Orientation Stage

   At the beginning of the lesson, the teacher provided an introduction to the importance of understanding the mechanics of breathing, particularly regarding lung volume and capacity. The teacher showed two props—a balloon and cotton—that would be used in the game. When shown the props, most students responded positively, demonstrated by spontaneous comments, interest, and focused attention on the teacher. The teacher then explained the rules of the game: the balloon was used to demonstrate differences in air volume from blowing out, and the cotton was used to assess the strength and stability of the exhaled breath. At this stage, students had demonstrated their readiness to participate in the game and understood the purpose of the activity.

2. Exploration and Implementation Stage

   This stage is the core of learning because students play the game directly. The game is played using two different media: balloons and cotton.

   a. Activities Using Balloons

      Each student was asked to blow up a balloon in three different scenarios: 1) blowing up the balloon using one breath, 2) blowing up the balloon using several breaths, and 3) blowing up the balloon to its maximum capacity. Next, students

observed and recorded changes in balloon size in each experiment. The variation in balloon size became a concrete representation of the difference in air volume in the lungs. The teacher guided students to relate these results to the concepts of tidal volume, inspiratory reserve volume, and vital lung capacity. The learning activity is shown in Figure 1.

Figure 1. Implementation of Learning Using Balloon Media

b. Activities Using Cotton Media

Cotton balls were used for the second game. Students blew the cotton balls as far as possible and then measured the distance the cotton balls moved using a ruler. In the second experiment, students were asked to blow the balls with a more controlled exhale to observe the difference in airflow. This cotton ball activity helped students understand the relationship between exhale force, breath control, and lung capacity in a simple yet concrete way. The learning activity is shown in Figure 2.

Figure 2. Implementation of Learning Using Cotton Media

3. Collaboration and Discussion Stage

Students were divided into small groups of four to five to discuss the results of the experiment. The discussion focused on the causes of differences in balloon size in each experiment, factors that influence the distance the cotton ball travels, and the relationship between the game results and the concept of respiratory physiology. Observations showed that most groups were active in the discussion. Students shared their findings, compared results, and provided explanations based on their understanding. The teacher acted as a facilitator by asking provocative questions such as, "Why does the balloon get bigger when blown up several times?" or "What affects the distance the cotton ball can travel?"

4. Concept Reflection and Elaboration Stage

In this stage, the teacher invites students to summarize the concepts of lung volume and capacity based on their gaming experiences. Students verbally re-explain terms such as tidal volume, inspiratory reserve volume, and vital capacity, then compare them with the game's outcomes. Afterward, students complete a learning achievement questionnaire containing indicators of conceptual understanding. The questionnaire data is used to measure the extent to which students understand the material after participating in game-based learning.

Based on the evaluation results, it was found that game-based learning significantly contributed to the understanding of the concepts of lung volume and capacity. Of the 37 eighth-grade students who participated in the learning, the average mastery of the material was 89%, indicating a "high" category. Analysis of the learning achievement questionnaire showed that most students were able to provide correct answers to indicators related to differences in air volume during each breathing activity, interpretation of balloon size, and the relationship between exhalation force and lung capacity. Students were also

able to correctly identify the concepts of tidal volume, vital capacity, and lung volume variation when asked to relate the results of the game to the physiological concepts learned. These data indicate that the experience of playing with balloons and cotton not only helps students understand phenomena concretely but also makes it easier for them to internalize abstract concepts.

In addition to demonstrating high academic achievement, student responses during activities and in the reflection questionnaire also reflected high levels of learning engagement. Most students stated that the game helped them understand concepts previously considered difficult because they could not be directly observed in the human body. Observations during the lesson confirmed that students tended to be more focused, actively engaged in discussions, and demonstrated good collaboration when comparing balloon size and cotton swab displacement. Some students were even able to provide additional explanations based on their group observations. This active engagement was a contributing factor to achieving high levels of material mastery, as game-based learning provided direct experience and visual feedback relevant to the respiratory process. Thus, high student mastery scores were in line with a more interactive, constructive, and enjoyable learning dynamic.

Discussion

The research results show that the use of game-based learning with simple media such as balloons and cotton wool can increase student engagement and understanding of the respiratory system, particularly lung volume and capacity. This finding aligns with the active learning principles of the Independent Curriculum, which emphasizes contextual, exploratory, and student-centered learning experiences.

The use of balloons to simulate changes in air volume provides students with a concrete experience in understanding the mechanics of breathing. This aligns with previous research that suggests science-based games can improve exploration skills and conceptual understanding through hands-on activities (Goslen et al., 2025) . Meanwhile, the use of cotton to measure exhalation strength supports psychomotor learning and provides a concrete visualization of lung capacity, reinforcing the findings of Zakaria et al. (2025) that the use of hands-on media can improve scientific argumentation and conceptual understanding.

The 89% student mastery rate demonstrates the effectiveness of the game-based learning approach. This finding aligns with the research of Araina et al. (2025) , which states that game-based learning can simultaneously address the cognitive, affective, and psychomotor domains and create a fun learning environment. Students' active involvement during the game also demonstrates that this model is capable of accommodating the characteristics of Generation Z, who require interactive and meaningful learning.

Furthermore, research findings support the notion that a variety of learning methods remains necessary despite the advancement of learning technology. Simple media such as balloons and cotton wool have proven effective as contextual teaching aids, as emphasized by Sharapova & Asqarova (2025) who argued that active, traditional methods remain relevant for fostering students' practical skills and independent thinking.

Overall, the integration of game-based learning into respiratory system instruction not only enhanced student understanding but also created a fun, collaborative, and contextual learning experience. This demonstrates that simple media can still have a powerful learning impact when used in an effective learning design.

CONCLUSIONS

Based on the overall research results, it can be concluded that game-based learning utilizing balloons and cotton media has proven effective in improving students' understanding of the concept of lung volume and capacity. The implementation of learning that follows the syntax of game-based learning—including motivation and orientation, exploration and implementation, collaboration and discussion, as well as reflection and elaboration of concepts—is able to create an active, contextual, and enjoyable learning experience. Students are directly involved in game activities, make observations, and relate the results of activities to physiological concepts through group discussions and collective reflection. The effectiveness of this approach is reflected in the average score of material mastery of 89% from 37 students, which indicates that most students understand the material well. Thus, game-based learning can be a relevant and easy-to-implement alternative strategy to improve the understanding of Biology concepts, especially abstract material such as the respiratory system.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this article.

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