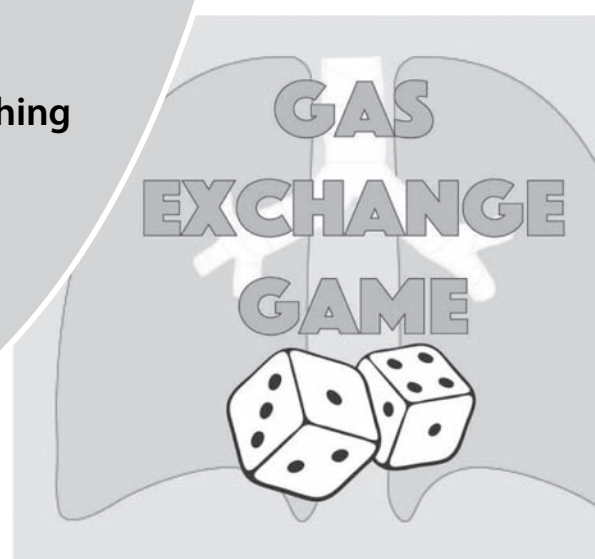


# Gas Exchange Gamified: Teaching Respiration Physiology with a Novel Board Game

KATIE WIBKING



## ABSTRACT

*Pulmonary gas exchange is a complex component of respiratory physiology. For many students, the movement of unseen gases can seem abstract and confusing. The “Gas Exchange Game” is a novel board game designed for use in a second-semester anatomy and physiology course. Students apply textbook knowledge of the laws of gas exchange and use the game board and pieces to see concrete examples of how gases move in the human body.*

**Key Words:** respiration; respiratory; pulmonary; physiology; gas exchange; game; lungs.

## Introduction

Research indicates that the use of games in classroom instruction can increase student learning. Because of their competitive nature and motivational psychology, games have the capacity to engage, challenge, and motivate students in a way that traditional classroom activities – such as lectures and group discussions – do not (Pho & Dinscore, 2015). Game play typically requires students to apply skills such as creativity, critical thinking, and collaboration, which have been identified as 21st-century workplace competencies (Burke, 2017).

This activity is designed for second-semester anatomy and physiology students at a two-year college, but it could also be used in an Advanced Placement high school setting. To play the “Gas Exchange Game,” students must first set up the game board and read through the rules together. Then they put those rules into practice. During game play, students compete against their classmates in small groups, motivating them to interact and enhance their knowledge of the subject matter together, in a fun, informal way. Instead of simply memorizing steps of the exchange process, students “see” the process in action by rolling dice and moving tokens and beads, thus helping them understand the concept of respiratory gas exchange.

This type of game-based learning also offers instructors a unique opportunity to evaluate student learning. As students play the game,

the instructor can observe and make notes regarding their use of critical thinking and problem solving. This kind of “stealth assessment” remains largely invisible to students, while still allowing the instructor to provide them with “real-time, just-in-time” instruction and feedback (Shute et al., 2009, p. 2).

Prior to game play, the instructor may opt to give a mini-lecture (5–10 minutes) on gas exchange. At least 30 minutes of class time should be allocated for game play. The materials required are listed in Figure 1.

## Preparation

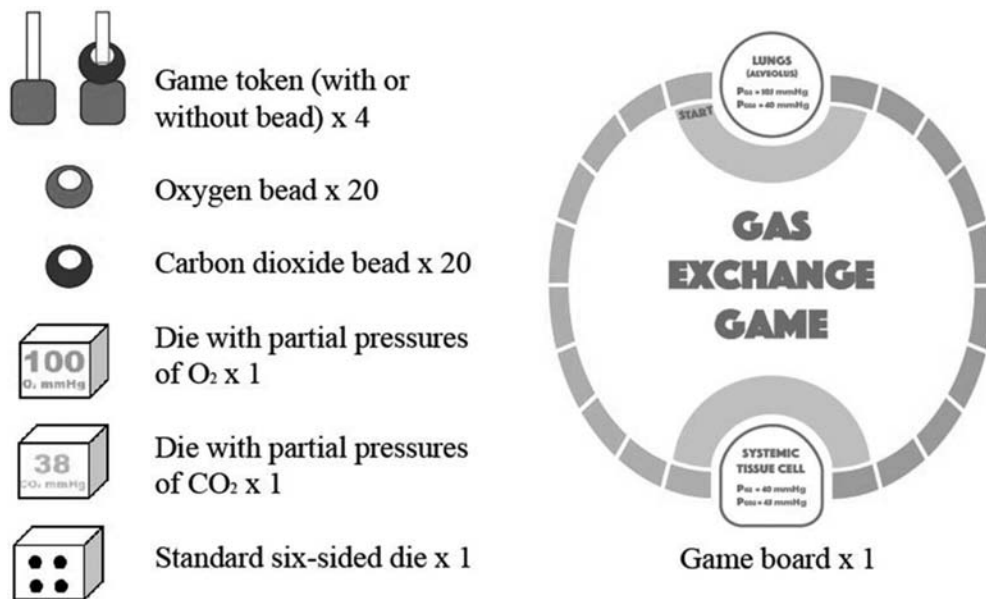
The board for the Gas Exchange Game was designed by the author and can be used, shared, and adapted, with attribution, for non-commercial purposes under the Creative Commons Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0) license (<https://creativecommons.org/licenses/by-nc/2.0/>). A printable game board is available as Supplemental Material with the online version of this article. It can be printed on standard letter-size paper or specially printed for a larger play area (recommended size: 18 × 18 inches). Red and blue beads can be purchased at any major craft store. Game tokens can be made by using air-dry clay and lollipop sticks. Blank dice can be purchased, and partial pressure values written on them with permanent marker (Table 1: custom dice values). Alternatively, custom dice can be made by custom game makers (e.g., <https://www.boardgamesmaker.com/>). Additionally, one regular die should be packaged with each game set.

## Instructions

The following instructions are provided to students.

### Objective

To exchange respiratory gases between the lungs and blood, and between the blood and body cells.



**Figure 1.** Materials for game play.

**Table 1. Custom dice values.**

Die	Side 1	Side 2	Side 3	Side 4	Side 5	Side 6
Partial pressure CO <sub>2</sub> (mmHg)	38	40	42	45	48	50
Partial pressure O <sub>2</sub> (mmHg)	28	36	40	100	105	108

## Setup

Each player selects a game token and places one blue bead on it. Players begin by placing their token on the board in the purple semicircle labeled “Start.” Place all of the red beads in the area labeled “alveolus.” Place the remaining blue beads in the area labeled “systemic tissue cell.”

## How to Play

- The Start position on the board is a purple semicircle that represents a pulmonary capillary, the site of external respiration.
- A player begins by rolling the red and blue dice. The numbers on the red die represent the partial pressure of oxygen ( $P_{O_2}$ ) in the blood, while the numbers on the blue die represent the partial pressure of carbon dioxide ( $P_{CO_2}$ ) in the blood.
- In order to advance past Start, a player must pass their blue bead ( $CO_2$ ) from their token in the pulmonary capillary to alveolar air, and also pick up a red bead ( $O_2$ ) from alveolar air to their token in the capillary. Each gas will diffuse from the area where its partial pressure is higher to the area where its partial pressure is lower. The partial pressures in alveolar air are on the board.
  - In order to get rid of a blue bead, the player must roll a number on the blue die higher than  $P_{CO_2}$  in alveolar air.
  - In order to pick up a red bead, the player must roll a number on the red die less than  $P_{O_2}$  in the alveolus.
- Once a player has dropped off  $CO_2$  and picked up  $O_2$  in the pulmonary capillary, they roll the standard die to advance through oxygenated blood until they reach the second purple semicircle.

- The second purple semicircle position on the board represents a system capillary, the site of internal respiration.
- In order to advance past the system capillary position, a player must pass their red bead from their token in the blood into the systemic tissue cell and also pick up a blue bead for their token. Each gas will diffuse from the area where its partial pressure is higher to the area where its partial pressure is lower. The partial pressures in the systemic tissue are on the board.
  - In order to get rid of a red bead, the player must roll a number on the red die higher than  $P_{O_2}$  in systemic tissue cells.
  - In order to pick up a blue bead, the player must roll a number on the blue die less than  $P_{CO_2}$  in systemic tissue cells.
- Once a player has dropped off their red bead and picked up a blue bead in the systemic capillary, they roll the standard die to advance through deoxygenated blood until they reach Start.
- First player back to Start wins!

## ○ Samples of Student Feedback

Overall reaction to the game has been mostly positive. Specific student feedback has included the following comments:

- “Seeing rolled numbers to determine movement out of alveolus into blood gave better understanding of the meanings and pressures pertaining to partial pressure of  $O_2$  and  $CO_2$ .”

- “I think the game was effective. I wish I could’ve gone another round to really learn and understand the exchange process.”
- “The game definitely helped! Hands-on learning always helps me be able to visualize when test time comes. Also, you walking around to answer questions helped, too.”
- “This helped me. I would have liked to have kept playing for more understanding. It was starting to click.”

## ○ Conclusion & Future Work

Preliminary student feedback on the Gas Exchange Game suggests that it may be an effective learning tool for many students. However, further research is needed to determine the efficacy of the game in increasing long-term understanding of these critical concepts in respiratory physiology. In addition, the game itself may be adapted in several ways.

Currently, progression through the game is essentially a matter of chance (depending on what numbers the players roll with the dice). A possible adaptation would be to also give the players a set of questions related to respiratory physiology. In order to proceed according to their rolls of the dice, players would have to first answer a question correctly. With smaller classes and/or longer class periods, this would likely be an easy enhancement to aid in student learning; however, it would also slow game play, such that it may not be feasible if time is more limited. Another possible adaptation would be to provide a brief demo of game play prior to splitting up students to play on their own.

Finally, the Teams-Games-Tournament (TGT) cooperative learning model could potentially be implemented in order to more strongly reinforce the concepts of respiratory physiology for students. One way to implement the TGT model would be to put students of different ability levels together on teams (e.g., four teams named by color – Red, Blue, Green, Yellow). The teams would complete the game’s rules together and do a trial run-through of the game to ensure that all teammates understand the rules and objective. After that portion of the class, the teams would be mixed (one player from each team) to compete against players from the other teams in a class “tournament.”

The team that ended up with the most winners from the tournament would be the overall victor. This model would allow for the element of competition (during the “tournament”), while the first setup and run-through of the game would foster cooperation among teammates because they would want their team to be well represented in the tournament. The TGT model’s combination of competition and cooperation provides for “the ultimate motivational jumpstart” (Silver et al., 2007, p. 57). Using the TGT model also helps “build student learning through repetition and variation” (Silver et al., 2007, p. 62). While repetition is helpful when learning new material, it can become tiresome for students. Therefore, having students review/reuse the material in different ways is key. The TGT model would allow for this by having students understand respiratory physiology concepts first independently, prior to game day; then cooperatively, with their teammates; and finally in competition during the tournament.

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KATIE WIBKING is an Assistant Professor of Biology at Roane State Community College, Oak Ridge, TN 37830; e-mail: [wibkingkr@roanestate.edu](mailto:wibkingkr@roanestate.edu).