402 - BME Design Excellence Award - Executive Summary

Teaching Model for Ventilation and Perfusion Mismatching

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During medical school, students are taught about the importance of ventilation/perfusion mismatching and the effects it has on the body. Oftentimes, the students have a difficulty understanding that a high Ventilation/Perfusion (V/Q) ratio leads to dead space ventilation, or wasted ventilation, and that a low V/Q can lead to hypoxemia, which is a condition where there is low oxygen concentrations in the blood. An interactive model representing the mechanisms underlying ventilation/perfusion mismatching would help students understand this concept.

West (2016) presents a hypothetical ventilation and perfusion model in his textbook, *Pulmonary Physiology* [1], that utilizes water pumps to simulate the movement of air into the lungs and blood flow. Dye shows the gas exchange occurring and oxygenation of the blood. By understanding the current designs for modeling ventilation and perfusion mismatching, three sets of ideas were created consisting of colored water, colored beads, and colored LEDs. Using the process of design matrices, colored LEDs were chosen to depict varying V/Q ratios.

The current design consists of a linear set of Adafruit Neopixel LEDs placed within a curved cutout of a 3D-printed base to represent a capillary. Using Arduino software, the LEDs are programmed to fade from blue to red to show deoxygenated and oxygenated blood and varying flow rates to show changes in blood flow within a capillary. Above the curved cutout is a circular cutout with Adafruit Neopixel Rings concentrically placed to represent the inflow of oxygen into the alveolus that diffuses into the capillary. Altering the rate the circular LEDs turn on, changes the amount of ventilation represented. Two sets of buttons allow the user to change the ventilation and perfusion rates to display different V/Q ratios. The resulting V/Q ratio is displayed on a LCD display that also states the corresponding flow rates for both the capillary and the alveolus.

Validation of the model's capability of improving human subject's understanding of ventilation perfusion ratios was conducted. A Google Form was created containing videos of the model followed by a series of questions. The videos display the model representing different ventilation perfusion ratios, and the questions analyze the user's understanding of the ratios in the videos and what they represent. The user's understanding was assessed on whether the ventilation perfusion rates increased or decreased between videos, the ventilation perfusion ratio depicted in the video, and the physiological state the ratio represented.

The device is able to demonstrate a variety of ventilation and perfusion ratios through manipulation of the rates of ventilation and/or perfusion. Through the changes in the rate of blinking of the LED lights, students are able to visualize and compare the ratios, which will help them to think critically about this concept. The addition of buttons makes the device easily manipulated by the user. It is able to be viewed through a document camera, making it easy for a lecturer to display it in a larger classroom, but it can also be used by individual students. It offers medical instructors an interactive teaching tool that was previously not available, and this will help medical students to learn about this difficult topic more easily than before.

[1] West's Pulmonary Physiology, Tenth Edition, John B. West and Andrew Luks, Wolters Kluwer, 2016, pp 70-71.