**Teaching Model for Ventilation and Perfusion Mismatching Product Design Specification**

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**Problem Statement:**

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. A model representing the mechanisms underlying ventilation/perfusion mismatching would help students understand this concept.

**Client Requirements:**

- The device needs to accurately model ventilation and perfusion mismatching
- The device should include an interactive component that will allow the user to change the ratios of ventilation and perfusion
- The device should be large enough to be seen in a classroom full of 180 people with the use of a projector or camera, yet small enough for easy storage
- The device is able to be used multiple times per lecture
- The budget for the project is $1000

**Design Requirements:**

1. **Physical and Operational Characteristics**

    a. **Performance Requirements:**
        - The device will likely be used in a classroom setting
        - Must model a range of ventilation/perfusion ratios
            1. Minimum of five settings: dead space ventilation, high V/Q ratio, 1:1 ratio, low V/Q, and shunt

    b. **Safety:**

- No open wires that could be harmful to the user
- No sharp edges or corners that could be dangerous during transport of the device

c. **Accuracy and Reliability:**
   - Students in the lecture hall need to be able to easily differentiate between the different settings
     1. When asked, users can correctly identify that the oxygenation of the blood has increased or decreased 19 out of 20 times when viewed on a screen as in a lecture

d. **Life in Service:**
   - At least five years

e. **Shelf Life:**
   - Electrical components must be of good quality so they will not degrade and need to be replaced

f. **Operating Environment:**
   - Will be used in a classroom setting
     1. Likely with use of document camera or projector
   - Portability of the device could mean there is a chance of damage between storage and classroom
   - Damage could occur if misused

g. **Ergonomics:**
   - People should be able to view the device on a screen from 14 meters away
   - People with visual impairments, such as color blindness, should be able to learn from the design

h. **Size:**
   - No more than 0.61 x 0.61 m (2ft x 2ft)
   - Maximum dimensions of 0.22 x 0.27 m (8.5 x 11 in)
     1. Must fit on a tabletop
     2. Must fit under a document camera

i. **Weight:**
   - Less than 6.8kg (15lbs)

j. **Materials:**
   - No Material Restrictions

k. **Aesthetics, Appearance, and Finish:**
   - No unfinished points, edges, or open wires

2. **Production Characteristics**

   a. **Quantity:**
      - Only one Ventilation/Perfusion Model will be needed for client's classroom

   b. **Target Product Cost:**
      - The product should remain under a total budget of $1,000

3. **Miscellaneous**

   a. **Standards and Specifications:**
      - Not applicable at this time

   b. **Customer:**
      - Easy to use for professors in medical school with no technical background
        1. Controller with different settings
      - Minimal set-up and reset time
        1. Maximum set-up time of two minutes
        2. Maximum reset time of one minute
      - Differentiation in color, brightness, or speed between blood coming to and leaving the lungs
      - Differentiation in color, brightness, or speed between air exerting and leaving the alveolus
      - Visible flow of blood

   c. **Competition:**
      - West's model for V/Q matching [17]
        1. Uses pumps and dye to show the effect of V/Q ratios on blood oxygenation
      - E-learning Computer Model for Cardiovascular System [18]
        1. Incorporated a Lumped Parameter Model (LPM) into an e-learning environment to create a tool to help students, undergraduate medical students, in particular, understand cardiovascular physiology, map disease progression, and classify the severity of a disease.
      - Circ-Adapt [19]
        1. A computational model of the pulmonary and respiratory systems that is used to investigate clinical aspects by incorporating mechanical and hemodynamic interactions.
        2. Contains flexible parameters to mimic various physiological states.

**References**

[1] J. B. West, “Chapter 5: Ventilation-Perfusion Relationships,” in *Respiratory physiology: the essentials*, Baltimore: Williams & Wilkins, 1974, pp. 70–71.

[2a] Warriner Dr, Bayley M, Shi Y, Lawford PV, Narracott A, Fenner J (2017) Computer model for the cardiovascular system: development of an e-learning tool for teaching of medical students. BMC Med Educ 17: 017-1058.

[2b] W.Dassen et al., "The application of complex research simulation models in education; A generic approach," 2011 Computing in Cardiology, Hangzhou, pp.465-468.