Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit
- Edit and reprint the base design with space for
- integrated microcontroller





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

ntensity vs Bri + 154 R² = 0.908	ghtness		Plot	of Silicon	(Capillar	y) LED Inte	ensity vs Bri 168 R ² = 0.675	ghtness	
			e Intensity Value 1 1	75 70 65					
			D Image	60					
			ageJ LE	55					
150	200	250	는 1	50	50	100	150	200	250
Brightness Input Value						Arduino LED B	rightness Input Valu	e	

Continue testing the final design

• Test ability to model V/P mismatching to a population Incorporate interactive component into the final design • In the form of buttons or dial

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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



Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi **Client: Dr. Christopher Green**

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.

Background

- Gas exchange occurs in the alveoli with ventilation (V) into the alveoli and perfusion (Q) into the bloodstream [1] High V/Q: dead space [2]
- Low V/Q: shunt
- Common diseases can cause mismatching [3]
- Mismatching can lead to hypoxemia [4]



Figure 3: Textbook diagram to model V/Q ratios with water [7]

STATE

Figure 4: Online simulation modeling V/Q ratios [8]





Figure 2: Diagram representing gas exchange [6]

- Water Model
- Powered Dye (ventilation)
- Water (blood flow) Concentration (V/Q)
- Circ-Adapt Computational (online) model of heart and circulation
- Adjustable parameters
- Focused on cardiac disease

Advisor: Dr. Amit Nimunkar

respective colors and flow rates.

Features:

Design Criteria

 Model ventilation and perfusion mismatching Includes an interactive component to display five important V/Q ratios Can be used multiple times during a lecture

 Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm

Less than 6.8 kg for easy portability and storage

· Withstand long periods of time in storage

Service life of 5 years

Materials

 3D Print PLA LED Flex Strip with Silicone Tube Adafruit Neopixel 16 Ring LED Arduino Uno

12V DC Power Supply Adapter

Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single

compartment representation of gas exchange between the modernam alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using



Total Cost: \$74.24

Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

· Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream

· Ring LED: Inserted into the alveolus to represent oxygen present using the color green and different blinking rates · Circle LED: Inserted into the bloodstream with use of red, purple, and blue

to represent the oxygenation of blood from the alveolus Arduino microcontroller: Programmed to alter LED brightness and flow







Testing / Results

Testing

- brightness ranging from Arduino values of 10-255
- 2 tests: alveolus and capillary, with 7 trials at different LED Took photos of the LEDs projected onto the screen Measured intensity with ImageJ
- Linear Regression T-Test
- Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent) exists
- Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

- 11874-1689-1088	- 1.000 - 1.000 - 1.000
	1-
	-
	· · · · · ·
Anisano LEE Maghimuu Apud Adus	Andalase 1.020. Recipitations in procession

Future Work

- Incorporate interactive component into the final design In the form of buttons or dial
- · Remodel the circuit integrated microcontroller
- Edit and reprint the base design with space for
- Continue testing the final design
- Test ability to model V/P mismatching to a population

Acknowledgements We would like to thank

References

[2] S. Integliata, W. G. Gossman, and A. Risso, "Physiology, Long Dead Space," 15-9869-2019. [3] Kavini, D., 2020. Featuration Performs Relationships. (antine) Conversionale value [4] Sastar M. Kirayan, N. and Baryal, P. 2017. Mechanizmi of hypercentra Long India, 33(1), p.47. S Stars gaugle cam. 2020. The Requiratory System - #SULPhyrics (Old Ster). Justine) [6] Shateestook.com. 2028. Alteenine Gas Exchange Palacanary Alteenine Alteenin Socii Fector (Reyalty Event 2208120008, Junited). [1] Wea's Publicancey Dynamicsy, Trees Edition. John R. West and Andrew Lake, Walnes Klasser, 2016, pp. 30-31. [3] W.Dossaw et al., "The application of complex research simulation models in education: A generic approach," 2013 Computing in Candidogy, Rangellum, pp.463–468.

Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness



- Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff
- [1] E. J. Widmain, A. J. Roulet, R. Paff, and K. T. Strang. <u>Enders</u> Januar physiology: the mechanisms of body Southers, Fifteenth Rev. Eek. McGraw-Mill Education, 2818.



Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிரி பிரி பிரி பிரி பிரி பிரி பிரி பிர				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.







Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிரி பிரி பிரி பிரி பிரி பிரி பிரி பிர				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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





Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிரி பிரி பிரி பிரி பிரி பிரி பிரி பிர				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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

Design Criteria

 Model ventilation and perfusion mismatching Includes an interactive component to display five important V/Q ratios Can be used multiple times during a lecture Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm

 Less than 6.8 kg for easy portability and storage Withstand long periods of time in storage Service life of 5 years



Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிரி பிரி பிரி பிரி பிரி பிரி பிரி பிர				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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

Materials

 3D Print PLA LED Flex Strip with Silicone Tube Adafruit Neopixel 16 Ring LED Arduino Uno 12V DC Power Supply Adapter Breadboard-Friendly DC Power Supply Mount



Total Cost: \$74.24





Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிரி பிரி பிரி பிரி பிரி பிரி பிரி பிர				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.

	Bloods
1	
	3D prin

Features:

- bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Base: 3D printed SolidWorks base modeling a single alveolus and

Ring LED: Inserted into the alveolus to represent oxygen present using the

Circle LED: Inserted into the bloodstream with use of red, purple, and blue

Arduino microcontroller: Programmed to alter LED brightness and flow

Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness





Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிரி பிரி பிரி பிரி பிரி பிரி பிரி பிர				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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

Testing / Results

Testing

- Measured intensity with ImageJ

Linear Regression T-Test

- exists
- but not applicable to Silicon LEDs



Arduino LED Brightness Input Value

 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 Took photos of the LEDs projected onto the screen

 Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

Linear relationship statistically significant for Circular LEDs

Arduino LED Brightness Input Value



Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிரி பிரி பிரி பிரி பிரி பிரி பிரி பிர				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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

Future Work Incorporate interactive component into the final design In the form of buttons or dial Remodel the circuit Edit and reprint the base design with space for integrated microcontroller Continue testing the final design Test ability to model V/P mismatching to a population







Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிரி பிரி பிரி பிரி பிரி பிரி பிரி பிர				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]

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



Acknowledgements We would like to thank Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff





Team Members: Brittany Glaeser, Kaitlin Lacy, Zoe Schmanski, Jenna Eizadi 🝟 💟 **Client: Dr. Christopher Green** Advisor: Dr. Amit Nimunkar

Abstract

Ventilation-perfusion (V/Q) mismatching explains the ratio between the air that reaches the alveoli in the respiratory system and the oxygen exchanged to the bloodstream. This concept is often challenging for medical students and there are currently no competing physical teaching models. The use of silicone diffused LEDs was chosen to depict V/Q ratios on a 3D printed base model of a single alveolus and single capillary. Testing was completed by determining the intensity of the LEDs through an overhead display to determine the optimal brightness to represent a variety of V/Q ratios. Future work includes incorporating buttons to separately increase and decrease ventilation and perfusion in order to represent a larger range of ratios, as well as incorporating a display to show the V/Q ratios.

Motivation

Ventilation and Perfusion mismatching is a difficult concept for medical students to visualize, specifically, how it can lead to dead space ventilation and hypoxemia. A device is needed to help the medical students conceptualize these different ventilation perfusion ratios and their consequences.



Design Criteria

- Model ventilation and perfusion mismatching
- Can be used multiple times during a lecture
- Visible to a lecture hall of 180 people with use of document camera; no larger than 22 x 27 cm
- Less than 6.8 kg for easy portability and storage
- Withstand long periods of time in storage • Service life of 5 years

Materials

- 3D Print PLA
- LED Flex Strip with Silicone Tube
- Adafruit Neopixel 16 Ring LED
- Arduino Uno
- 12V DC Power Supply Adapter
- Breadboard-Friendly DC Power Supply Mount

Final Design

The current prototype for the V/Q mismatching teaching model is a single compartment representation of gas exchange between the Bloodstream alveolus and the bloodstream at the capillary. LEDs were used to represent different levels of oxygen flow using respective colors and flow rates.



Figure 5: The 3D printed base including a single alveolus and the bloodstream with LEDs to represent V/Q ratios.

Features:

- Base: 3D printed SolidWorks base modeling a single alveolus and bloodstream
- color green and different blinking rates
- to represent the oxygenation of blood from the alveolus





Figure 6: Depiction of the ring LED to represent increased oxygen by increasing brightness

• Includes an interactive component to display five important V/Q ratios

Total Cost: \$74.24

• Ring LED: Inserted into the alveolus to represent oxygen present using the

• Circle LED: Inserted into the bloodstream with use of red, purple, and blue

• Arduino microcontroller: Programmed to alter LED brightness and flow



Testing

- exists





Future Work

- Remodel the circuit





- [5] Sites.google.com. 2020. The Respiratory System WHS Physics (Old Site). [online]
- [7] West's Pulmonary Physiology, Tenth Edition, John B. West and Andrew Luks, Wolters Kluwer, 2016, pp 70-71.

Testing / Results

• 2 tests: alveolus and capillary, with 7 trials at different LED brightness ranging from Arduino values of 10-255 • Took photos of the LEDs projected onto the screen

Measured intensity with ImageJ

Linear Regression T-Test

• Test to determine if a linear relationship between LED brightness(independent) and measured intensity(dependent)

• Linear relationship statistically significant for Circular LEDs but not applicable to Silicon LEDs

175	— 0.0298*x +	168 R ² = 0.675		
175 175 175 175 175 175				
ອີຊິ <u>ມີ</u> 160				
ப்பட திற்று பிர்க்கு பிர்கு பிர்கு பிர்கு பிர்கு பிரி பிர்கு பிர்கு பிர்கு பிரிக்கு பிரி பிரிக்கு பிரிக்கு பிரி பிரிக்கு பிரிகு பிகு பிகு பிரிக்கு பிரிக்கு பிரிக்கு பிரிக்கு பிரிக்கு பிரிகு பிகி பிகு பிகு பிகு பிகு பிகு பிகு ப				
는 150 50	100	150	200	250
	175 170 170 165 160 160 155 150 150	0.0298*x + 175 170 165 160 155 150 150 100	- 0.0298*x + 168 R ² = 0.675	 0.0298*x + 168 R² = 0.675 175 165 160 155 150 100 150 200

 Incorporate interactive component into the final design • In the form of buttons or dial

• Edit and reprint the base design with space for

integrated microcontroller

• Continue testing the final design

• Test ability to model V/P mismatching to a population

Acknowledgements

Dr. Christopher Green Dr. Amit Nimunkar BME Faculty and Staff

[1] E. P. Widmaier, A. J. Vander, H. Raff, and K. T. Strang, Vanders human physiology: the mechanisms of body function, Fifteenth. New York: McGraw-Hill Education, 2019. [2] S. Intagliata, W. G. Gossman, and A. Rizzo, "Physiology, Lung Dead Space." 15-May-2019.

[3] Karius, D., 2020. Ventilation-Perfusion Relationships. [online] Courses.kcumb.edu.

[4] Sarkar, M., Niranjan, N. and Banyal, P., 2017. Mechanisms of hypoxemia. Lung India, 34(1), p.47.

[6] Shutterstock.com. 2020. Alveolus Gas Exchange Pulmonary Alveolus Alveoli Stock Vector (Royalty Free) 239128069. [online]