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ARVO Annual Meeting Abstract | June 2024

Inspiring interest in eye research by bridging engineering and ophthalmology in high school

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Investigative Ophthalmology & Visual Science June 2024, Vol.65, 4217.
doi:

Abstract

Purpose : To bridge engineering and ophthalmology research in a high school course that inspires discovery-driven learning and critical thinking via cutting-edge research applications.

Methods : The content of Engineering I (John Bapst Memorial High School, ME, USA) was redesigned to learn engineering design process, documentation, modeling, research techniques, and iteration by addressing cutting-edge research questions in ophthalmology. The course learning objectives are summarized in Fig. 1. Starting from common reading and discussion of published research articles, students are prompted to identify interesting engineering questions within the field, formulate the problem statement, design experiments and protocols to investigate the problem, iterate to fine-tune the strategy, and present the process and the results in a professional manner.

Results : Offered in Fall 2023, the course enrolled 21 students in grades 9-12 (Fig.1), who were divided into 6 groups with 3-5 students per group. Each group self-selected eye-related engineering questions, including building a physical model to simulate how the ocular vasculature may respond to changes in pressure inside or outside the vessels (Fig. 2). Much effort was put into finding appropriate materials to use to mimic human

tissues. The utility of liquid latex, which can be applied in layers over a dissolvable 3D printed mold was a favored approach. Another group looked at an electric circuit design that is used as an analog for the blood flow in the intraocular region, and built and tested the electrical circuit in its physical form.

Conclusions : Through study of the eye and design of models consistent with its properties, students developed significant appreciation for and knowledge of ocular anatomy and physiology. Student learning was driven by real problems, yielding a higher level of engagement and ownership than previous years. Students have been exposed to peer reviewed research, learning how to read and decipher work that is years ahead of their educational level. Intentionally integrating engineering and ophthalmology may help excite the next generations of scientists and clinicians who will work effectively and collaboratively to advance disease understanding, cure, and care.

This abstract was presented at the 2024 ARVO Annual Meeting, held in Seattle, WA, May 5-9, 2024.

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Learning Objectives

1. Describe the anatomical structure and functions of the eye.
2. Understand the fundamental biological principles related to fluid dynamics and pressure in a biological system.
3. Understand how physical models can relate to biological systems.
4. Understand how to interpret research and conceptual frameworks in an engineering exploration and exercise.
5. Develop an appreciation for the use of software and computational aids in developing models and conceptual frameworks for model development and simulations.
6. Construct physical models that represent the blood vessel network within the eye.
7. Develop an understanding of how engineering simulations and models can help us to better understand potential health implications of specific circumstances in an analogous biological system.
8. Collaborate effectively in teams and learn to break down tasks in a way that leverages resources available within that team.
9. Communicate technical ideas and findings through written reports, diagrams, oral presentations, and visual aids.

Course Enrollment

Grade	*Number of Students*
9th	5
10th	5
11th	10
12th	1
Total	**21**

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Learning objectives and course enrollment

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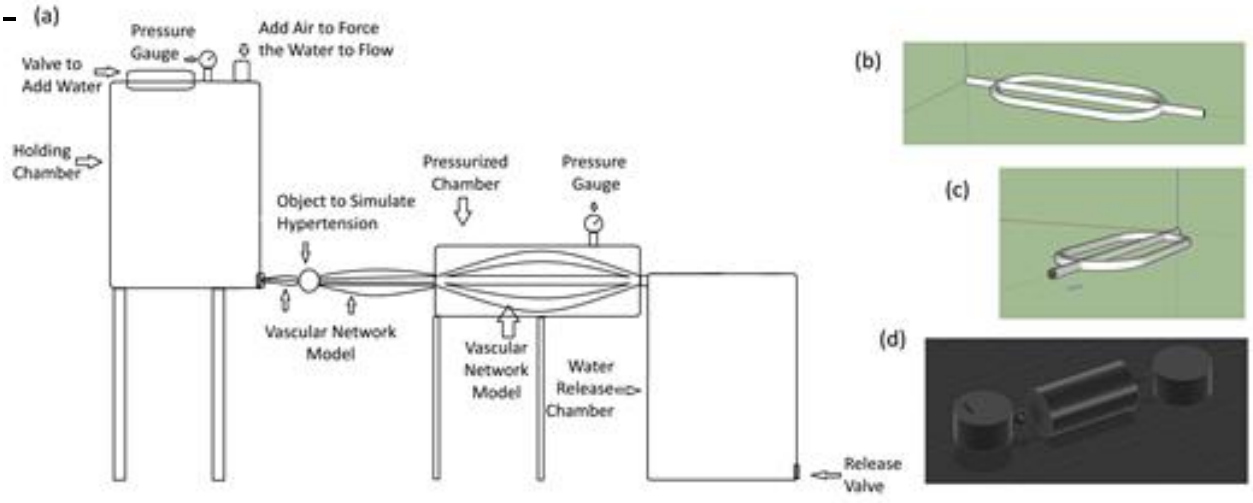

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Students' design to study the ocular vascular response to changes in internal and external pressure (a). CAD design of 3D printed vessels (b,c) and of the overall system (d).