Implementation of Engineering Projects in a High School Anatomy Course (WIP)

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Introduction

This Work-In-Progress is striving to introduce high school anatomy students to engineering and influence their perception on why engineering is important in the medical field. Students that hope to enter the medical field need opportunities to work on engaging problems that will help them develop creative and critical thinking skills that they can use in their future careers [1], and "thinking like an engineer" can help students develop those skills. The Science and Engineering Practices set by the Next Generation Science Standards (NGSS) propose that students need opportunities to 1) develop and use models, 2) plan and carry out investigations, and 3) construct explanations and designing solutions [2]. This project hopes to meet the Science and Engineering Practice standards by implementing engineering projects into an Anatomy 2 course during their cardiovascular system unit. In addition to being aligned to standards, the authors also wanted to measure growth in student mindset about the importance of engineering in the medical field. Various summer opportunities exist for high school students to learn more about biomedical engineering [3, 4], but this model suggests implementing it directly into the high school curriculum to reach more students that may not have considered a career in engineering. This pilot study aimed to assess the feasibility of conducting a full study about the potential benefits of this curriculum implementation.

Methods

A high school anatomy teacher and a graduate student and faculty member in Electrical and Computer Engineering partnered to implement the projects. A pilot study was conducted with eight students in an Anatomy 2 course. At the beginning of the unit, students were given a research topic: comparing mechanical and electrical ways to measure activity of the cardiovascular system. The students learned about the anatomy and function of the heart in traditional lessons led by their Anatomy 2 teacher, but these lessons were also supplemented with engineering activities with pulse meters and electrocardiograms (ECG). At the end of the unit, students participated in a final project where they designed and tested a hypothesis using the pulse meter and ECG. Survey data were collected to look for changes in student perceptions about engineering and the medical field.

Pulse Meter and ECG Engineering Activities

Throughout the course of the unit, students were able to learn more about electrical and mechanical ways to measure cardiovascular activity. The author created and led an engineering activity where students built and tested their own pulse meter using an Arduino and basic electrical components. The pulse meter itself consisted of three main parts: 1) a bright LED that shines through the finger, 2) a photoresistor whose value changes based on measured light intensity, and 3) an Arduino, a microcontroller that can take inputs from the photoresistor and output a graph that users can read. The components are connected as shown in Figure 1. As blood flows through the finger, the light reflected off the finger varies, changing the resistance of the photoresistor. The Arduino then reads an analog voltage from the circuit and displays it to a graph (Figure 2). This allows students to visualize blood moving through the finger, a mechanical way to measure cardiovascular activity. During their design process, the students were encouraged to "think like an engineer" and strive to make a device that was accurate in different environments, easy to use, and comfortable for the patient. They also were able to think fundamentally about how pulse meters in the medical industry work and what sorts of things biomedical engineers need to keep in mind when designing them. The students then learned how to use a commercial ECG sensor, allowing them to compare the mechanical measurements from their own sensor and the electrical measurements from the commercial ECG sensor.

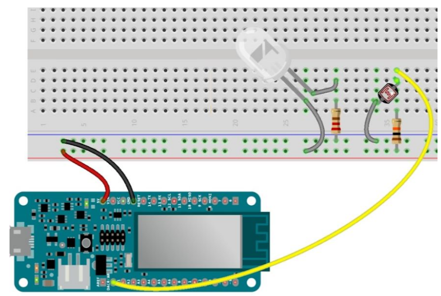
Figure 1. Diagram of the completed pulse meter circuit.


Figure 2. The complete pulse meter set-up with graph output on computer

Final Engineering Lab

The final assessment of the cardiovascular unit was for students working in groups to create and test a hypothesis relating to measuring cardiovascular activity. The students worked in groups of two to three and took data with their pulse meter and a commercial ECG. One student group compared baseline cardiovascular activity to activity after hearing a text tone, watching a scary movie, or listening to chewing noises by graphing the ECG readings measured. Another group measured ECG activity before and after walking, running, drinking coffee, and discussing the tragic death of a TV show character. Students were expected to write a final lab report that included a problem, introduction, data, and conclusion. An example of data collected by a student group are shown in Figure 3.

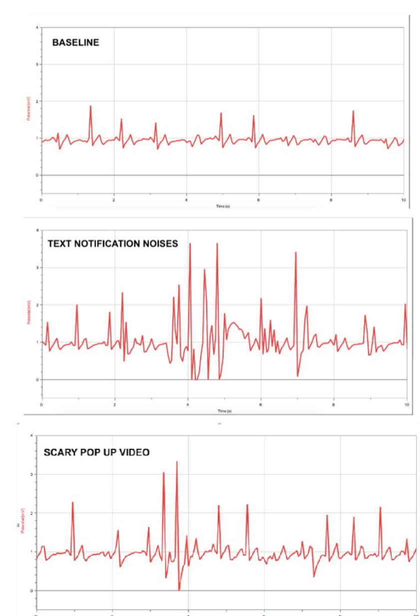

Figure 3. Example of data collected by a student group during their cardiac lab

Data Collection

Each student took a pre- and post- survey asking questions about their experiences. The pre-survey asked questions about Anatomy 1 which was taught without engineering projects, and the post-survey asked questions about Anatomy 2, specifically the cardiovascular unit that implemented engineering activities and a lab. These surveys were distributed through Google Forms, and each student chose a unique number that could be used to match their pre- and post-survey while keeping all student responses anonymous. All questions on the surveys were on a 6-Point Likert Scale from 'Strongly Disagree' to 'Strongly Agree'.

Results

Survey results are summarized in Table 1 and Figure 4. Table 1 shows measures that were taken in both the pre- and post- survey and compares them. A Paired Student T-Test was performed on each of these metrics, and the P-Value is also listed. Bolded P-Values show statistical significance. Figure 4 shows the results of metrics that were only taken during the Post-Survey and compares student attitudes towards the Pulse Meter Activity and Engineering Lab.

	Pre-Survey		Post-Survey		
Question	Mean	SD	Mean	SD	P-Value
I feel confident that the content I learned in (Anatomy 1/Anatomy 2) will help me reach my goals.	5.43	1.13	5.00	1.53	0.200
I feel confident that the skills I learned in (Anatomy 1/Anatomy 2) will help me reach my goals.	5.29	1.11	5.00	1.53	0.172
(Anatomy 1/Anatomy 2) was difficult for me.	2.86	1.21	2.71	0.95	0.689
I felt stressed about completing my work in (Anatomy 1/Anatomy 2).	3.29	1.60	2.43	1.13	**0.0453**
The things we learned in (Anatomy 1/Anatomy 2) will help me in college.	5.14	1.07	5.29	0.76	0.604
The things we learned in (Anatomy 1/Anatomy 2) will help me in a future career.	5.29	1.11	5.00	1.41	0.359
(Anatomy 1/Anatomy 2) helped me decide what I wanted to do for a career.	5.29	0.76	4.29	2.21	0.156
I found the information in (Anatomy 1/Anatomy 2) interesting.	6.00	0.00	5.14	1.86	0.270
I understand what an engineer does.	3.375	1.408	4.71	1.604	0.188
I understand why engineers can be important in the medical field.	3.57	1.27	5.29	.76	**0.0300**

Table 1. Summary of the results of the Pre- and Post-Surveys taken by the students.

Discussion

The results of this pilot study have demonstrated potential benefits of incorporating engineering activities into high school anatomy courses. The students met each of the three science and engineering practices developed by NGSS. They successfully developed and used a circuit to model a pulse meter, planned and carried out an investigation related to measuring activity of the heart, and constructed explanations about changes in heart activity based on the data they collected. The activities introduced in this study helped high school anatomy students understand how engineers can be important in the medical field in a low-stress environment. There was also no perceived negative effect on what or how students were learning. Aspects of the unit that the students liked included the "extensive lab that challenged everyone", "hands on learning", "being able to be independent", having choices, and using technology.

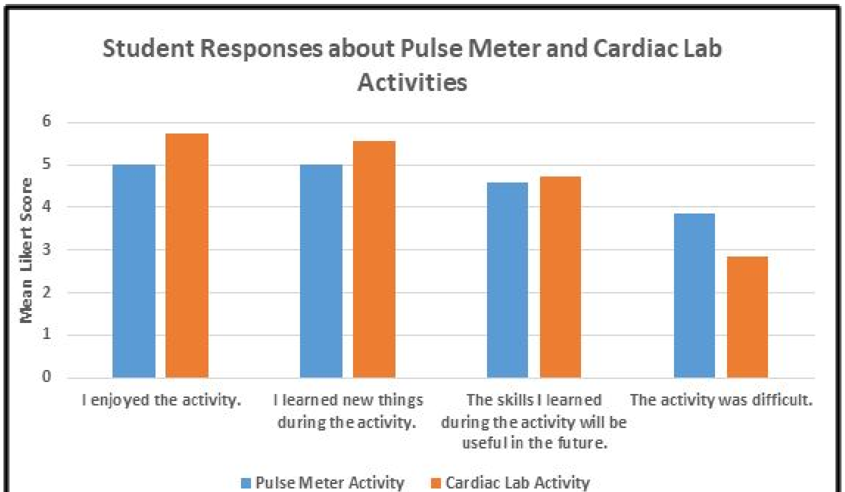

Figure 4. Data collected from student post-survey.

Future Work

In the future, the authors hope to continue to expand and include engineering activities in more anatomy courses. The sample size in this pilot study was small, so we would like to see this done with a larger group. In addition, we would like to conduct interviews with students to get a better idea of how implementing these activities improves critical and creative thinking. We would also like to explore how the implementation of these activities affects student performance on more traditional assessments.

Conclusion

This pilot study has shown that there is promising potential in adding engineering activities and labs in high school anatomy courses to help students understanding how engineering is used in medicine. This implementation helped students learn more about biomedical engineering while practicing their creative problem solving, hands-on lab work, and technical writing. These activities fill the gap caused by lack of opportunities to work on engaging problems related to the human body, preparing students better to work in the medical field. Our recommendation is to perform a complete study with more students and the ability to conduct interviews. Implementation of these activities and labs could better prepare students to be creative and critical thinkers, and therefore, better health professionals.

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