Out Reach Report

BME 402

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1.0 Out Reach Event Summary

As engineers, we are driven to gain and implement knowledge. However it is not simply enough for us to apply the knowledge we have gained, we must also pass only this knowledge and our passion for design. To do this, our design team took part in Badger Ridge Middle school's annual science expo, were we introduced seventh and eighth graders to the field of biomedical engineering. We presented to six different groups of students throughout the day. Each presentation lasted 25 minutes and included a group of 15 to 20 students. We started each presentation by explaining our individual fascinations with engineering, and the specific reasons we decided on becoming biomedical engineers specifically. After expressing our motivation, we presented to the middle-schoolers three sub focuses in the biomedical engineering field, biomechanics, bioinstrumentation, and tissue mechanics. After explaining these sub focuses, we involved the students in an activity showing the product of biomedical engineering, an electrocardiogram. Using this activity and through describing our personal experience in biomedical engineering, we hoped to introduce and intrigue the students to the field of biomedical engineering.

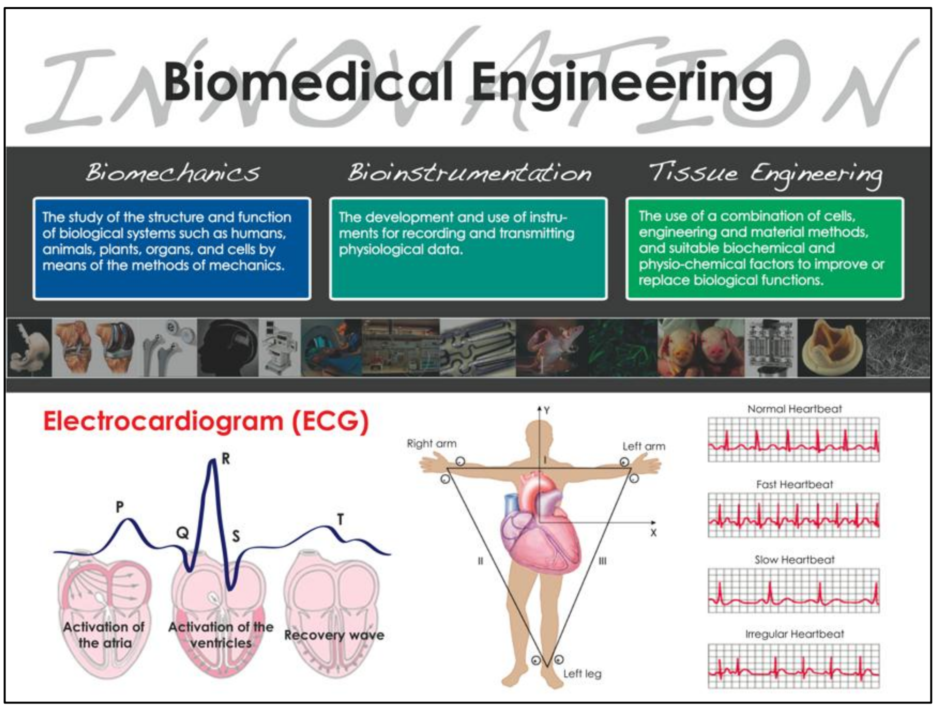

Figure 1. Poster introducing BME and ECG. A poster that sums up the three major fields in BME for the students. The bottom half of the poster is the Electrodiagram for students reference along with our explanation throughout the activity.

2.0 Motivation of entering BME undergrad program

In order to get the students excited about biomedical engineering, each of our team members started by introducing ourselves and telling the students their personal reasons for becoming a biomedical engineering. By doing this, we hoped to make a connection with the students and show them that there is a wide range of backgrounds in biomedical engineering.

2.1 Alan Meyer's Motivation

Alan told his story of how he was inspired by the anime (Japanese cartoon show) Full Metal Alchemist from when he was in 7th grade. In this show, the main character (Ed) looses an arm and a leg in an alchemic experiment. After this happens, Ed receives a replacement robotic arm and leg. This concept of robotic replacement body parts intrigued Alan to the point that he decided that making these robotic limbs is what he wanted to do in the future. There was a mixed reaction to Alan's story from the middle-schoolers. In some groups, nobody had heard of the show, so the effects of the story were not overly intense; however, in other groups, there were several students (and even one teacher) that had not only heard of the show, but were fans. Hopefully, from Alan's story, the students now have an exciting image of the development, implementation, and possibilities that prosthetics have to offer and will seek to become biomedical engineers so that they can make this image come true, just as Star Trek inspired the development of technology in the space age.

2.3 Wan-Ting Kou's Motivation

Engineering was on Jessica's mind since high school because she was not interested in business or other areas of study. She was not sure which engineering major to pick when she first entered UW-Madison. After attending the intro to engineering she realized there is a major that combines biology with engineering, which make her think that is a perfect match for her because she is also interested in biology at the same time. She emphasized the fact that BME combines the engineering aspect with the biology, which is the biggest attraction to her, and hopefully this emphasis could also strike some students' mind. Jessica then told the class that there are 4 different tracks, or concentrations, in BME, and she is currently focusing on Tissue Engineering. This would lead to the further introduction of Tissue Engineering.

3.0 Introduction to Biomedical Engineering

3.1 Biomechanics

After describing why our team members are attached to biomedical engineering, we presented three sub focuses in our field. Alan began by describing biomechanics as: the study of the structure and function of biological systems such as human, animals, plants, organs, and cells by means of the methods of mechanics. After the "textbook definition", Alan described different example of how and where biomechanics are applied in the real world. Alan started by talking about prosthetic devices, relating biomechanics to the story he told when introducing himself. Alan started by describing some of the different types of upper-arm prosthetic devices, including body-powered, myoelectric models, and hybrid models. These three types were chosen to show the range of study that is currently going on in the prosthetic fields. By comparing these different models, Alan showed how there are benefits and drawbacks for different prosthetics, leaving opportunities for future engineers to come up with innovative solutions. From the description of different prosthetics, the comment that seemed to intrigue the students the most was the concept that a machine could be attached directly to a human and be controlled just by thinking.

After describing how prosthetics fit into biomechanics, Alan began to expand the students' perception of the field by using two of his past classes, Tissue Mechanics and Mechanics of Motion. Alan described the importance of biomechanics in the development of pre-, current, and post-surgical recovery. By knowing the different mechanical properties and limits of tissues, it has been possible for biomedical engineers to develop equipment and limitations to help improve surgical success rates. Along with knowing the mechanics of tissue, it is important to know the forces that act while moving. To illustrate this, Alan described how motion capture is used in calculating the forces on the body during different movements like running, jumping, and biking. To give the students an image of this, Alan used the example of how physics and animation is done for movies and video games, such as golem in Lord of the Rings.

3.2 Tissue Engineering

Jessica then began to talk about what is Tissue Engineering since she is currently concentrating on this track. By definition, tissue engineering is the use of combination of cells, engineering and material methods, and suitable biochemical and physio-chemical factors to improve or replace biological functions. Typical applications involve engineering the biomaterials that can be applied to human body system. Think about engineer something at the molecular level. We can alter the cells by changing its gene expression in order to change their behavior. We can add some soluble factors into a biomaterial so it can help your cells heal faster. We can add a drug into a gel and the drug can be delivered and released at the destination you want in your body. Another hot topic will be about the stem cell. In the future growing a biocompatible organ for replacement for several diseases may be possible. Since Albert is currently participating in a lab and his research involves stem cells, he continued to talk about what stem cell.

Stem cell is currently one of the hottest topics in tissue engineering. Stem cells, by definition, are special cells that frequently undergo self-renewal to maintain their stem cell properties and are able to differentiate into various kinds of specialized cells in the body. The research lab that Albert is working on throughout my undergraduate career focuses on study of adult stem cells called mesenchymal stem cells (MSCs). MSCs can be derived from adult bone marrow and are able to differentiate into cells such as osteoblasts (bone forming cells), chondrocytes (cartilage forming cells), muscle cells, and fat cells. The goal of the lab is to derive MSCs from patients, then culture the cells in petri dish to induce cell differentiation of a particular type of specialized cells, and eventually put the tissue which composed or produced by the specialized cells back to patient's diseased area to promote the healing process.

3.3 Bioinstrumentation

The third biomedical engineering topic discussed was Medical Instrumentation. The discussion started with John by asking students if they if they had ever used a medical instrument, the answer being that every student has surely used a medical device. Medical devices can be anything that monitors or helps regulate biological functions, and their use is extremely widespread. The simplest medical device talked about was a digital thermometer, which uses a resistor ("thermistor") that can change in resistance at different temperatures. The circuit within the device is able to detect the resistance, and relate it to the correct temperature. Many students had been inside an MRI machine, and its function was explained so that they better understood the device that had been used to examine their bodies. MRI (Magnetic Resonance Imaging) is the best technology available to examine soft tissues in the body, and is commonly used to diagnose a variety of symptoms such as brain tumors, torn ligaments, and cancer. The MRI creates a strong magnetic field around the patient, which causes the protons within the body to align. Radio waves are then sent into the molecules, and they emit energy that can be picked up by magnetic coil. The information picked up by the coil can then be processed, and a detailed image is created of the area scanned. MRI is safer than using x-rays or CT scans because it does not use potentially dangerous radiation that ionizes molecules. Another medical device described was the pacemaker, and some students recognized the device because their grandparents had them. The pacemaker helps monitor a person's heartbeat, and assists with the regulation of a normal heartbeat. Pacemakers are able to detect irregular heartbeats, and it will send electrical pulses to the heart to establish a normal rhythm. Some recently-developed pacemakers can even help regulate things such as breathing and body temperature by changing the rate at which the heart beats. The description of common medical devices was a good transition to the Electrocardiogram, which is also very commonly used, and was the interactive demonstration for the students.

4.0 EKG Activity

In order to stimulate the student's interest in the field of biomedical engineering we decided to use the portable EKG USB device that was developed in at the UW-Madison Bioinstrumentation lab. By using something that was developed by biomedical engineering, and actively taking various students EKGs, we were able to leave a fun and exciting memory of what it is like to be a biomedical engineer. We explained how the three electrodes measure the potential differential on the skin and record it using through the USB circuit using java code. The differential changes at the different stages of the heartbeat cycle, as was explained in the background physiology. Although the students were not overly excited as to how it works, they thoroughly enjoyed seeing a real-time graphical display of their heart beating to the point that several of the kids were interested in making their own.

4.1 Physiology Background of Heart

The heart contains four major chambers: right atrium, right ventricle, left atrium, and left ventricle. The right side of the heart receives deoxygenated blood from veins all over the body and pumps blood into the lungs where the blood will get re-oxygenated. The left side of the heart receives this oxygen-rich blood from the lungs and then pumps it to the rest of the body. The blood delivers nutrients and oxygen to tissues throughout the body while picking up carbon dioxide and wastes at the same time. The veins return low-oxygen blood to right atrium, and the cycle begins again.

ECG diagram can show the electrical activities of the heart as measured by the electrodes placed on the skin of right and left arms. The specific components of the waveform are described later.

The heart rate is determined by pacemaker cells called the SA node, which constantly fire electrical signal to other pacemaker cells and heart muscles. The heart muscles receive electrical signal and then contract to help heart pump blood. As the atrium filled up with returned blood, the pressure builds up within the chamber. When the pressure in atrium is higher than in the ventricle, the heart valves between the two chambers will open and allow blood flow from atrium to ventricle. The muscles of atriums then contract after receiving the signal from SA node so that more blood is pumped to the ventricles. This event is coincided with the p wave in the ECG diagram. P wave represents the depolarization of the atrial muscles, meaning the cell membrane potential become more positive as the electrical signal is received. When the ventricle builds up enough blood pressure, the atrial valve closed and the ventricle starts to contract. Again, the muscle contraction is initiated by the depolarization of the ventricular muscles, which is represented as the QRS complex. QRS complex is much bigger than the p wave because ventricle has to pump blood to all over the body and thus is a much bigger tissue than atrium. After the ventricle pump blood out of the heart, the ventricular muscles will undergo repolarization, which brings the membrane potential of muscle cells back to normal. This is represented as the T wave.

4.2 Student Reactions

The general feedback and reaction from the students are positive. The first group of students was not so excited about the activity probably because the presentation started after lunchtime, and we did not manage the time of the entire presentation too well. We realized that they needed to be energized to engage with the presentation. After getting the feedback from the first group, we reorganized the presentation and added more interesting information to our presentation. From the second group to the last, student reactions were all positive (see Appendix for pictures captured by Jessica). The students were fascinated by watching their own heartbeat changing when they got nervous, or when they held their breath. Students were also eager to volunteer to perform the ECG test once they saw the first one gone through. We were able to allow multiple students to experience the activity. When some of the students got a little out of control, the teacher would step out and manage the situation. Teachers played a big role to energize the students as well. After the activity, students began to build some interest in BME, and if there was time left, we introduced our current 402 design project. We brought the poster from last semester to show how the BME program looks like in UW-Madison. Students and teachers began to have several questions regarding to the things we have done, or the future of the BME in career.

5.0 Appendix

Figure 2. Explanation of the ECG during activity. Alan explaining the ECG diagram as the volunteering students performing the activity. The students were fascinating by the change of the trend on the diagram.

Figure 3. Student reaction. Students were paying attention to Alan about the ECG diagram, as well as the further discussion about BME program.

Figure 4. Interaction between students. The students tended to explore the effect of holding breath on the ECG diagram. They experimented themselves and found out the change. We then explained the possible reason for the change they observed.

Figure 5. Presentation about current design project. If time permitted, we showed the poster from last semester and gave a brief description about our current 402 project. The purpose was to show how the design course in BME benefited us as an engineer.