Bioengineering workshops for 6th-12th grades

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Abstract

Bioengineering is a rapidly growing field with increasing interest at all levels. K-12 engineering workshops are valuable to bolster both interest and understanding at an impressionable age. Bioengineering demonstrations, presented to an uncontrolled audience, can be challenging because of the multi-disciplined nature and/or need for IRB approval. This paper describes bioengineering workshops conducted for an Expanding Your Horizons in Science and Mathematics Conference, whose goal is to introduce young women in grades 6 through 12 to a variety of diverse and challenging careers, and encourage their interest in science and mathematics. These one hour bioengineering workshops typically involve a brief introduction followed by a hands-on portion. A description of the objectives and design of the workshops, student feedback, and recommendations for future direction for improving their impact on student learning and appreciation of bioengineering are reported.

Background

The Annual San Joaquin County Expanding Your Horizons (EYH) in Science and Mathematics Conference is held in early October at the University of the Pacific in Stockton, CA. This conference is sponsored by the University of the Pacific School of Engineering and Computer Science, Lawrence Livermore National Lab and Sandia National Lab. The San Joaquin EYH conference, which has been hosted at the University of the Pacific for the past fifteen years, is one of more than 140 that are held around the country each year through the Expanding Your Horizons Network in Oakland, CA.

The primary goal is to introduce young women in grades 6 through 12 to a variety of diverse and challenging careers, and encourage their interest in science and mathematics. At the conference, participants attend hands-on workshops where they meet people who will make an impact on the choices they make about their future.

Extensive studies conducted by the Center for Science Education (CSE) at Education Development Center, Inc., (EDC)[1] have shown that hands-on science provides the process of discovery that will help to not only capture interest of young people that may not have considered science as an area of interest, but also helps build on such skills as critical thinking, problem solving and teamwork.

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Hands-on exploration is many times termed inquiry or discovery learning. The studies conducted by CSE looked at the impact of inquiry learning, specifically in science instruction, which has moved from the presentation of purely textbook material to a much more hands-on approach.

Other studies conducted support the movement towards more activity-based science. Kyle et al.[2,3], and Haury and Rillero[4] indicated that having a more activity-based environment, when introducing science topics, can improve students' attitude toward science. One requirement for all of the workshops conducted at the Expanding Your Horizons Conference is to include a hands-on experience for the participants. Within a short amount of time (approximately one hour per workshop), the presenters need to capture the students' interest and provide them with an exciting and memorable learning experience.

This paper describes three bioengineering workshops conducted for an Expanding Your Horizons in Science and Mathematics Conference at the University of the Pacific. Bioengineering demonstrations, presented to an uncontrolled audience, can be challenging because of the multi-disciplined nature and/or need for IRB (Institutional Review Board) approval. Knobloch[5] reports on a bioengineering module designed for girls entering ninth through twelfth grade. Koppel et al.[6] also reports on the attraction between biomedical engineering and girls. King et al.[7] reports on an optional one unit course the freshman year at Vanderbilt University. A description of the objectives and design of the workshops, student feedback, and recommendations for future direction for improving their impact on student learning and appreciation of bioengineering are reported.

Methods

Following a keynote speaker, one hour workshops are repeated three times throughout the day. For each workshop there is typically a 20 min introduction followed by a 20-30 min hands-on portion for the participants. Depending on the topic, background and/or safety concerns, workshops may need control over the age of participants. Ages can be broken down into two groups: middle school (6^{th}-8^{th} grade) or high school (9^{th}-12^{th}). Three bioengineering workshops will be described.

a. "Bioengineering Body Bingo" Workshop

This workshop is essentially a hybrid of Bingo® and Jeopardy®. Following a twenty minute overview of a range of medical devices, placards are distributed to four person teams. These placards indicate an outline of a human body. Each team is then given a random, but equal number of medical device game pieces, e.g. artificial hips, pacemakers, contact lenses etc. The game "host" then proceeds to state clues. For example, "the Scarecrow needed a brain, the Cowardly Lion needed courage and the Tin Man needs…" The first team to raise their hand with an "artificial heart" answer receives some candy, and if they have the appropriate game piece, they can place it on the placard. Another example involves "This device enhances vision, but they are hard to see." The first team/person to answer "contact lenses" wins this question and so the game proceeds. The first team to place all medical devices on the placard "wins" and they receive a prize. Time permitting, this process is often repeated two to three times and the random

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component often results in different winning teams. This workshop was designed for 6th-8th grades, but can also be used for 9th-12th grades.

b. Artificial Chicken Knee Workshop

This workshop is designed to simulate artificial knee replacement. Following a presentation on the anatomy of the knee and some background on knee replacement surgery, four person "surgical teams" are provided four chicken drumstick bones with the objective to produce two artificial knees. These bones have been significantly baked and then soaked in bleach. Figure 1 summarizes the following artificial knee assembly. Each person is expected to cut, using a mini hacksaw, the ends off the chicken bones with one bone representing the femur and the other representing the tibia. Chrome grommets, with stainless steel woodscrews placed through the grommet and into the exposed marrow, are used to simulate the stainless steel femoral and tibial components. Artistic license is used with Velcro® to simulate the plastic spacer. This is necessary in order to connect the femoral and tibial components. This workshop was designed for 9th-12th grades with some safety concerns regarding the mini hacksaws.

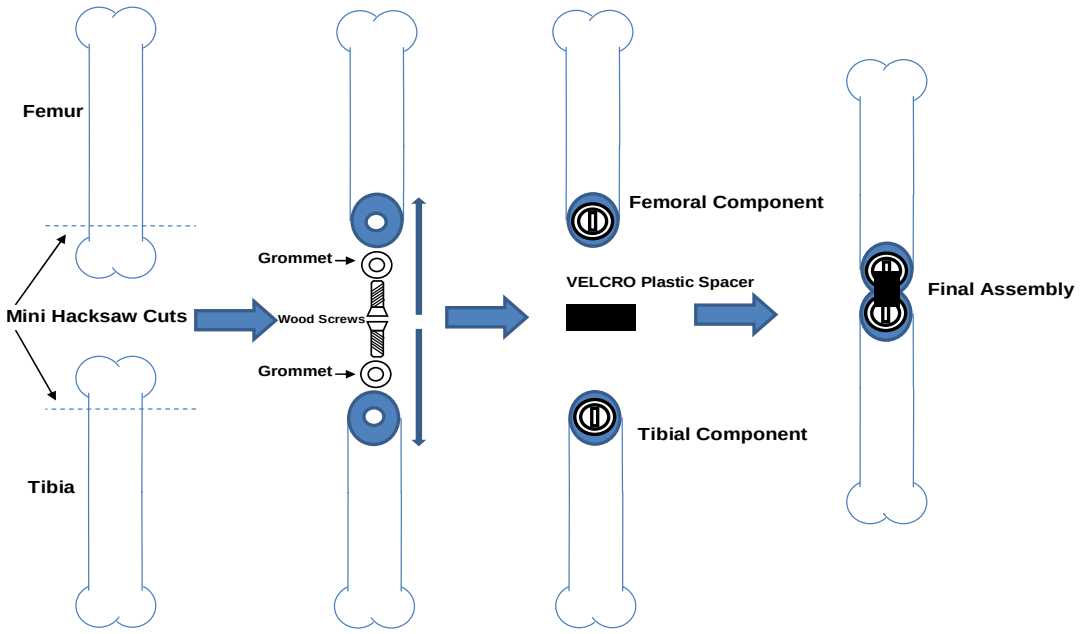

Figure 1. Artificial knee assembly.

c. Intraocular Lens Workshop

This workshop is designed to simulate intraocular lens surgery. Following a presentation on the anatomy of the eye and some background on cataracts, four person "surgical teams" are provided a

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Halloween mask with grapes placed in the eye sockets to simulate the eyes. The mask is chosen to simulate the facial dimensions and the corresponding spatial logistics. A lunch tray serves as a "sterile instrument tray" containing a dissecting knife, tweezers and two sequins to simulate the intraocular lenses. The grapes are incised and the sequins carefully inserted. Time permitting, this process can be repeated so that every person performs this procedure. This workshop was designed for 9^{th}-12^{th} grades with some safety concerns regarding the dissecting knife.

Results and Discussion

Each participant was asked to evaluate the workshop in the final 5-10 minutes of the session. A five point scale was defined with 1 being "dull", 2 being "So-So", 3 being "OK", 4 being "Pretty Good" and 5 being "Great!" The "*Bioengineering Body Bingo" Workshop* received an average of 4 ± 1 (N = 129). The *Artificial Chicken Knee Workshop* received an average of 4 ± 1 (N = 36). The *Intraocular Lens Workshop* also received an average of 4 ± 1 (N = 44) with the simulated eye surgery reported as "the best thing about the workshop." These results are rather impressive given the random nature of the participants, i.e. the workshops are not pre-selected.

Safety is paramount and any cutting requires close supervision. Many of the *Artificial Chicken Knee Workshop* participants had never used a hacksaw before. One safety item of note is that the mini hacksaw blades would become dull over the course of the day. In the future, new blades will provided for each session. The actual cutting of the bone was consistently reported as "the best thing about the workshop." When asked "how to improve this workshop," one participant requested real human bone!

In the spirit of full disclosure, candy was often the prize for correct answers throughout the *"Bioengineering Body Bingo" Workshop.* This is a remarkable way of promoting participation and is highly recommended. This candy was often reported as "the best thing about the workshop" and "losing" reported as the worst part.

Finally, these bioengineering workshop concepts were originated as part of a project within an upper class BENG 103: Biomaterials course. Instructor approved workshops were presented by these upper class students. The decreased age gap between the undergraduate presenters and EYH participants is viewed as a positive to promote interaction, and the realization that this is something that they, the participants, too can do. Conducting the actual workshop is an excellent experience for the upper class students because it highlights the need for knowing ones audience.

Conclusions

Given the logistics of bioengineering demonstrations, these aforementioned bioengineering workshops simulate medical device implantation procedures for a relatively uncontrolled audience and without the need for IRB approval. Given the positive feedback from workshop participants, this may stimulate interest yielding future bioengineering undergraduates.

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