SB³C2017
Summer Biomechanics, Bioengineering and Biotransport Conference
June 21 – 24, Tucson, AZ, USA

‘EXPLORING “ME”CHANICS: THE MULTISCALE MECHANICS OF ME!’ SUMMARY OF OUTREACH LESSONS LEARNED

Stephany Santos (1), Hannah Kackley (1), David M. Pierce (1,2)

(1) Department of Biomedical Engineering
University of Connecticut
Storrs, CT, USA

(2) Department of Mechanical Engineering
University of Connecticut
Storrs, CT, USA

INTRODUCTION

Eighty-two percent of 16 and 17 year-olds in the UK believe engineering is a vital key for the future of technology innovation, yet only 21% are interested in engineering careers [1]. Many factors could contribute to such statistics, for example: perception of need for natural ability in math and science, reputation of engineering as a difficult subject, notions that engineering is not for women, and more. Perceptions like these do not take hold in high school, but rather at much earlier, even as young as pre-primary education age.

During previous outreach activities we asked a group of K-1 girls, “What do engineers do?” One kindergartner immediately raised her hand and exclaimed, “They drive trains!” A partial list of the students’ ideas regarding engineering jobs includes: drive trains, build trains, make cars, build planes, build bridges, and fix computers. Nearly 85% of the responses indicated that engineers create transportation related machines or infrastructure. The last response connects to engineers and technology, but the keyword “fix” implies that engineers do not create but only find solutions when something goes wrong. This representative handful of responses misses the breadth of engineering tasks, and furthermore the breadth of fields, e.g. biomedical engineering.

To successfully respond to increasing global demand, the US must increase domestic enrollment and retention in STEM areas currently in decline [2]. Our broad objective as educators is to positively impact the attitudes, behavioral intentions [3], and learning of a wide range of students – from underrepresented elementary school students to active researchers – by integrating multiscale biomechanics research with education and outreach activities.

In this effort we have developed an outreach event targeted specifically at female middle-school students as this is a crucial age to foster STEM interest [4] and challenge stereotype threats [5].

METHODS

We designed an event titled, “Exploring MEchanics: The Multiscale Mechanics of Me!” to introduce students to biomedical engineering, biomechanical analysis, and our research in cartilage biomechanics. We developed four interactive stations for students to visit at their own pace. The content translates our research on structure-function relationships across length scales in biomechanics using simple models that middle school students can make, deform and take home.

Station 1: Your body is a machine. At this station, we introduce students to some of the 360 joints in the body and the common joint motions of flexion, extension, adduction, abduction, and rotation. Students explore their own joint motion using XBox® Kinect Skeletal View, and a biomechanics-inspired ‘Simon Says’ game (Fig. 1).

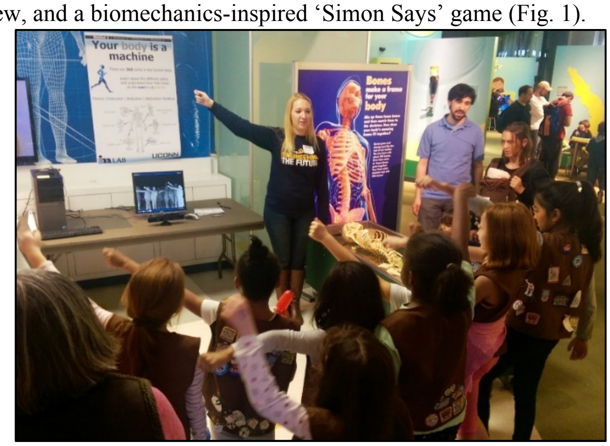

Figure 1: At Station 1 students explore their own joint motion using XBox® Kinect

Station 2: You kneed tension to function. At this station we introduce students to muscle tension, and how muscles work in pairs to create movement in the knee. Students build a joint and use balloons to represent the quadriceps and hamstring muscles. With movement they observe muscle tension/compression during knee flexion/extension.

Station 3: Cartilage helps you move freely. At this station students learn that cartilage facilitates smooth joint motion and naturally absorbs shock in our joints. We introduce students to the terms *viscoelastic* and *biphasic*, and explore the general properties of cartilage using "oobleck," a non-Newtonian fluid made of cornstarch and water.

Station 4: Looking from the inside out. At this station, students look at a slide of human cartilage through a microscope, and begin to understand its microstructure and function (Fig. 2). Students create special drawings that, when stained, reveal their own "histology" image.

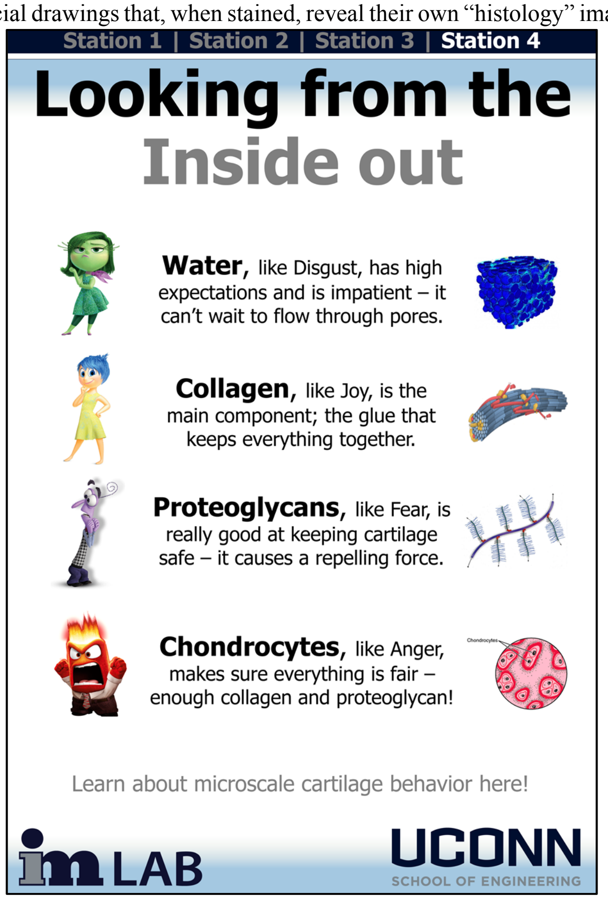

Figure 2: Sample poster. This poster helps students understand cartilage constituents, and microscale structure and function.

To deliver this outreach event we actively partner with the Connecticut Science Center, particularly the Women in Science Initiative, as well as Danbury Public Library (both in Connecticut). We hosted events run by Stephany Santos, a Ph.D. candidate in the PI's lab, and supported by undergraduate women Hannah Kackley, Phoebe Szarek, and other women from the PI's course BME 3600W "Biomechanics." We completed an initial test event at the Connecticut Science Center on Dec. 12th, 2015, and a follow-up at Danbury Public Library on Dec. 7th, 2016. The latter event served PK-6 grade students in a community with more than 40% Hispanic population.

In a post-survey, we asked students participating in the event: (Q1) Have you previously heard of biomedical engineering?; (Q2) What was your opinion of science and engineering BEFORE attending Exploring MEchanics? (rank on a scale of 1-6); (Q3) What was your opinion of science and engineering AFTER attending Exploring MEchanics? (rank on a scale of 1-6); and (Q4) What is one thing you learned today?

We flagged the following keywords from Q4: Cartilage, Force/Compression/Tension, Muscle/Contraction, Knee, and Cells. In addition, we attributed responses as being most related to station 1 and 2, 3, or 4. We ran a Wilcoxon Rank Sum test to probe connections among age, race, gender, and Q1-4.

RESULTS

Our preliminary data is only from the event at Danbury Library. Unfortunately there were no statistically significant correlations. Instead we summarize the general trends. From the survey responses, Q1 revealed that only white male participants recognized the term "biomedical engineering" prior to attending the event. Looking at improvements in score from Q2 to Q3, every surveyed female ranked their opinion of science and engineering higher, whereas males either remained equal or improved. Specifically, half of the females reported a score of less than 3 for Q2, compared to one quarter of the males.

In the open-ended Q4, all student responses were macroscale, relating to stations 1 or 2. None of the students chose to include "cells" or the microscale in their responses. Female students tended to include the keyword "cartilage," while males often included the keyword "knee." Responses mentioning the structure-function relationship of cartilage and the knee were only given by 4th and 5th grade students.

DISCUSSION

Our event exposed students to biomedical engineering, many for the first time. Q1, in our study of PK-6 students, seems to align with the common stereotype that engineering is only for white males. Female affinities to science and engineering improved through participation in our event. This is promising, and demonstrates that outreach events like these can improve the perceptions of female students. Our survey showed that the females had a lower initial liking for STEM, but the interactions with female role models appeared to have a positive effect.

Students responded well and retained information about macroscale biomechanics. Responses such as, "I learned that there's a cushion on your joint so when you bend it, it doesn't get damaged," indicate a direct impact from our event, and an initial understanding of biomechanics of the knee. Many students visited the large-scale mechanics station last, so Q4 may be influenced by the lapse in time.

For many of the students, this event provided their first view through a microscope. Further, several students had no prior knowledge of cells, or even their existence. Thus, while this first exposure is important, it was often hard for them to conceptualize.

Future improvements will include multiple microscale stations to help students better understand what they cannot see with the naked eye alone. Utilizing techniques such as macroscale metaphors, repetition, and more experiments may improve outcomes on the microscale. We hope to expand this outreach by bringing the event (min. 2× per year) directly to local middle schools.

ACKNOWLEDGEMENTS

Cailah Carroll, Kristen Rose, Phoebe Szarek, and Alyssa Wilczynski. The Connecticut Science Center and Danbury Public Library.

REFERENCES

[1] McDonald C, *ComputerWeekly.com*, March 16, 2016.
[2] National Science Board, *Science and Engineering Indicators*, 2014.
[3] Ajzen I and Fishbein M, *The Handbook of Attitudes*, 173-221, 2005.
[4] Lemming J, *DecodedParenting.com*, March 11, 2014.
[5] Spencer SJ et al, *J Exp Soc Psychol*, 35:4-28, 1999.