UNIVERSITY OF FLORIDA CENTER FOR PRECOLLEGIATE EDUCATION AND TRAINING (CPET)
BENCH TO BEDSIDE 2016 PROGRAM
ACTION RESEARCH FINAL REPORT

"So what are you going to do with your life?"

A survey of student perceptions of pursuing a career in Biomedical Engineering

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Abstract:

In my seven years of teaching college-bound students, I have only had two or three students express an interest in engineering and only one had prior knowledge of biomedical engineering. The purpose of this action study is to determine if students have prior knowledge of the field of biomedical engineering and if not, to determine if exposure to topics and hands-on experiences in biomedical engineering will stimulate interest in pursuing a career in biomedical engineering. Students will participate in pre- and post- experience surveys about their perceptions and interest in pursuing a biomedical engineering career. In between the surveys, students will be exposed to a variety of topics in biomedical engineering and hands-on experiences to expose students to the field of biomedical engineering and stimulate interest.

Rationale:

In my three years of biology, and four other science classes at Jupiter High School, I never heard once about the field of biomedical engineering. I only knew about general engineering topics from my calculus and physics classes, as well as several friends who were pursuing degrees in mechanical and electrical engineering in college. My perception was that engineering was largely math-based, and since calculus and physics had the potential to induce panic attacks and crying jags, I had no interest in being an engineer of any sort. However, I loved biology and chemistry, so I found a career in marine biochemistry that eventually transitioned to a teaching career.

I am blessed to teach pre-collegiate and collegiate level classes in my high school and my students are very interested in all sorts of biology and biochemistry topics. One topic we have never discussed in class as a career (nor have I heard discussion among the students) is biomedical engineering. Project Lead the Way has concluded that engineering is a topic rarely discussed in traditional high school classroom settings (Metz, n.d.). Jackson and Ellis (2008) believe “If engineering is presented in a manner that emphasizes its relevance to our daily lives, the impact will be tremendous. Such infusion must start as early as possible in the educational development of students and be consistently reinforced throughout each grade level, if a long term solution to the current decline in interest in engineering is to be found.” My personal experience with biomedical engineering in a hands-on format at UF CPET was quite the epiphany (Hudalla, 2016). I could actually do biomedical engineering without math and I found it very

interesting! I wondered, “What might I have done with my life if I had been provided with that experience during my high school years?”

Therefore, I am resolved to introduce my students to the career possibility of biomedical engineering this academic year. My students should be made aware of this potentially exciting career path. My area of focus will be on presenting cutting edge topics in biotechnology and biomedical engineering, as well as the opportunity to play biomedical engineer. I hypothesize that exposure and hands-on experience to topics in biomedical engineering will increase interest in pursuing a career in biomedical engineering. My students have curriculum standards that address the use of biotechnology and this additional exposure will support that curriculum goal.

Action Research Intervention:

The intervention that I am implementing in my biology classes is exposure to a seldom-discussed field of study: biomedical engineering. This intervention will be conducted with college bound freshman students in the Pre-AICE Biology program who are experiencing their first high school level science class. Although I intend to make this a year-long introduction to the wonder of biotechnology and biomedical engineering, for the purpose of this study, it will focus primarily on topics relevant to curriculum presented in the first semester (cells, membrane transport, cell division, DNA replication, protein synthesis, and genetics) and will culminate in hands-on biomedical engineering exercises in the first week of the second semester. My students will use two modules produced by Dr. Gregory Hudalla at the University of Florida: Building a Catheter to Remove Plaque Buildup in Arteries and Designing Protective Drug Coatings. My students will develop skills in literature and content-based comprehension, mental creativity, inquiry-based testing and methods assessment.

Changes to Action Research Intervention:

There were no changes to the student-based intervention of this action research into methods of stimulating interest in biomedical engineering as a career. However, I did not receive a favorable participation response from the Biomedical Engineering Society regarding the survey of current engineers. Thus, I have eliminated that portion of the intervention due to a lack of cooperation by the BMES leadership that resulted in a dearth of data.

Connections to Bench to Bedside Summer Institute:

The purpose of UF's CPET Bench to Bedside program is to present different topics in biomedical engineering and biotechnology to teachers so that those experiences may be incorporated into the student curriculum with the purpose of enhancing their science learning experience and stimulating student interest in careers in science. This lesson is a direct application of the biomedical engineering lessons we experienced on Friday, June 17, 2016 in Bench to Bedside with Dr. Hudalla and his graduate students. The myriad of interesting topics we encountered in other lectures with Bench to Bedside presenters (like *Caenorhabditis elegans* as a model organism and tissue decellularization to produce ghost organs) will also be used throughout the first semester to stimulate student interest in the career of biomedical engineering. Equipment will be borrowed from UF-CPET via the equipment locker system.

Students will be given a survey at the beginning of the year during discussions about the nature of science and careers in science. This survey will query their perceptions of engineering and prior knowledge of biotechnology and biomedical engineering. After clearly defining biomedical engineering, the survey will also assess their willingness to consider a career in biomedical engineering and technology. The same survey will be given after the semester-long introduction to biotechnology and biomedical engineering and after the two biomedical engineering hands-on exercises. I would also like to survey individuals who have chosen a career in biomedical engineering about their exposure to biomedical engineering as a career possibility and when and why they made that career decision.

Data collection and analysis:

The survey cohort consisted of freshman, with 51% being female and 49% male. The number of students whose parents/guardians are engineers was 67%, which was close to the number who had any outside experience with engineering/engineers (60%). During the course of the intervention, the number of students that understood the definition of engineering stayed the same at about 46%, the number who understood the definition of biotechnology increased from 27% to 65% and the number who understood the definition of biomedical engineering increased from 24.0% to 53%. This trend supports my supposition that my students' knowledge was limited to their interactions with engineers in daily life, but that most were probably not familiar with engineering specialties like biomedical engineering. Prior to the intervention, words that most students associated with engineering included mathematics, computers, design, building, technology, machine, intellectual, and hard. These words selections

reflected a pervasive perception that engineering is for “smart people who like math and have the ability to use technology to build machines, etc.”

Students participated in a variety of biotechnology and biomedical engineering activities during November and December of 2016 and January 2017. Students enjoyed learning to pipet and applying that skill to the determining the IC_{50} dose of a drug designed to fight cancer. Of the biomedical engineering activities, 68% preferred designing a pill coating compared to 32% preferring to design an angioplasty device. Students preferred the pill coating activity because “it was more creative”, “involved less math” and at the same time “felt like real life.” Students felt the angioplasty project was difficult given the materials provided and one student commented that he “didn’t enjoy the thought of going into someone’s artery and having your success or mistake be a life threatening motion.” Following the biomedical engineering web quests and lab experiences words that most students associated with engineering were discovery, biology, life, medical, create, save, help, life, cool, science, and fun. Student interest in considering a career in biomedical engineering/biomedical technology increased from 31% to 42%. Strength of interest (4 or 5) in pursuing a career in biomedical engineering/biotechnology increased from 8% to 21%.

My high school is very focused on music and so I was not surprised to find that not many of my students would consider a career in science, not to mention biomedical engineering. I was delighted to see their responses overall to the activities and heartened to see that that exposure increased student interest in biomedical engineering and biotechnology. That response reinforced my feeling that students need more exposure to STEM in general, but in particular, clarification of misconceptions about biology-based careers in technology would lead more students to consider that career path. I was frustrated to see the lack of interest on the part of the Biomedical Engineering Society in responding to my survey. There was a part of the survey that focused on asking for ideas of activities that would further stimulate student interest in biomedical engineering. As a teacher, I felt let down by BMES in my quest for novel means to capture students’ attention and focus it on the possibility of a career in biomedical engineering and biotechnology. One would think that BMES would be interested in promoting their career path to students, but that did not appear to be the case.

***Literature cited**

Hudalla, G., Ph.D. (2016, June 17). *Biomedical Engineering*. Lecture presented at UF - CPET - Bench to Bedside in University of Florida, Gainesville, FL.

Jackson, H. V., Ph.D., P.E., & Ellis, E. A., Ed.D. (2008). Early and Continuous Exposure to Engineering as a Profession: Career Imprinting in Grades PK-12. In *ASEE Annual Section Conference Proceedings*. Retrieved June 23, 2016, from https://www.asee.org/documents/sections/northeast/2008/Early-and-Continuous-Exposure-to-Engineering-as-a-Profession-Career-Imprinting-in-Grades-PK-12.pdf

Metz, S. S. (n.d.). What is Engineering and Why Encourage Students to Consider this Field?: Project Lead the Way (PLTW) Facilitates Career Exploration for Students. Retrieved June 23, 2016, from https://www.nae.edu/File.aspx?id=61965

Permissions: I don't believe it will be necessary to obtain any permission to pursue this study with the students. Our principal is very supportive of data-driven education and broadening the horizons of students. However, if I simultaneously survey the biomedical engineers, that might require IRB approval.

Budget & Justifications: There were no changes to the justifications for this research intervention. The materials and shipping were kindly provided by grants awarded to University of Florida's Center for Pre-collegiate Education and Training.

Appendix 1: Lesson Plan

TITLE: So what are you going to do with your life, and is it geeky?

KEY QUESTION (S): What does it mean to be a biomedical engineer and would you ever consider it as a career option? What are some cool topics in biomedical engineering? How has biotechnology been important in your life?

SCIENCE SUBJECT: Pre-AICE Biology

GRADE AND ABILITY LEVEL: Grade 9 Honors

SCIENCE CONCEPTS: Cells and tissues, osmosis and membrane transport, cell division and cancer, DNA replication and protein synthesis as related to genetic conditions, biotechnology and biomedical engineering

OVERALL TIME ESTIMATE: 2 Days for hands-on biomedical engineering design experiences

LEARNING STYLES: Visual (articles / videos), auditory (discussions), and kinesthetic (hands-on activities).

VOCABULARY:

Day 1: Building a Catheter to Remove Plaque Buildup in Arteries

Angioplasty
Artery
Atherosclerosis
Catheter
Plaque

Day 2: Designing Protective Drug Coatings

Diffusion
Drug Delivery
Efficacy
Encapsulation
Engineering Design Process

LESSON SUMMARY:

This lesson designed by Gregory Hudalla, Ph.D. will cover the principles of design in biomedical engineering. This content will be covered in two hands-on lab exercises in which students will role play biomedical engineers creating new designs and testing their designs for efficacy: Day 1: Building a Catheter to Remove Plaque Buildup in Arteries and Day 2: Designing Protective Drug Coatings.

STUDENT LEARNING OBJECTIVES WITH STANDARDS:

The student will be able to...

1. Design and construct a device to remove plaque from an artery in the shortest time with the least amount of damage to the patient and with the least amount of materials.

SC.912.N.1.1 Define a problem based on a specific body of knowledge , applying the scientific method to solve the problem and evaluate the solution.
SC.912.L.14.36 Describe the factors affecting blood flow through the cardiovascular system.

2. Design and construct a pill coating to maximize efficacy of drug delivery time with the least amount of discomfort to the patient and with the least amount of materials.

SC.912.N.1.1 Define a problem based on a specific body of knowledge , applying the scientific method to solve the problem and evaluate the solution.
SC.912.L.18.2 Describe the important structural characteristics of monosaccharides, disaccharides, and polysaccharides and explain the functions of carbohydrates in living things

MATERIALS: 8 UF CPET equipment locker boxes containing supplies as outlined in lesson plans by Dr. Hudalla.

BACKGROUND INFORMATION: Please reference the lesson plans designed by Dr. Gregory Hudalla, to explore the principles of design in biomedical engineering: Building a Catheter to Remove Plaque Buildup in Arteries and Designing Protective Drug Coatings

ADVANCE PREPARATION: Request and obtain equipment lockers from UF CPET SETS.

PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:

Day 1: Building a Catheter to Remove Plaque Buildup in Arteries

1) Introduce concept of heart disease/atherosclerosis caused by plaque formation in arteries via presentation (10 minutes)
2) Give students a locker box of materials and ask them to construct an angioplasty/catheter device to remove plaque from an artery in the shortest time with the least injury to the patient from the smallest number of materials (15 minutes)
3) Have students present device to class to determine efficacy of design (15 minutes)

Discussion Questions:

What are the important factors to take into account when designing this device? (Speed of removal, method of removal, safety to the patient)

Day 2: Designing Protective Drug Coatings

1) Introduce concept of drug delivery time in the digestive tract and the need for drug encapsulation to maximize efficacy of drug delivery. Access prior knowledge/experience of taking pills to discuss pill coating design and demonstrate pill coating dissolution using skittles and club soda (10 minutes).
2) Give students a locker box of materials and ask them to construct a pill coating that will enable the pill to be dissolved after the proper amount of time in the digestive tract. (15 minutes)
3) Have students present pill coating to class to determine if pill encapsulation meets time needed for proper delivery in the digestive tract (15 minutes)

Discussion Questions:

What are the important factors to take into account when designing the pill coating? (Coating breakdown speed, safety of coating materials, ease of coating application)

ASSESSMENT SUGGESTIONS:

Score each group (score of 1-5 for each type of criteria, with 5 being best) based on the following criteria for Building a Catheter to Remove Plaque Buildup in Arteries: time to remove device, method of removal, damage to patient, and number of materials.

Score each group (score of 1-5 for each type of criteria, with 5 being best) based on the following criteria for Designing Protective Drug Coatings: time to dissolve pill coating, size of pill, and number of materials.

EXTENSIONS:

ACTIVITIES: Are there other activities you know of from other resources that relate to this lesson? No

LITERATURE: Are there trade books, novels, journal articles, or other print materials that focus on the same topic(s) as this lesson? Not that I know of at this time.

RESOURCES/REFERENCES:

The following lesson plans by Gregory Hudalla, Ph. D., University of Florida will be used with the students…

Building a Catheter to Remove Plaque Buildup in Arteries

Designing Protective Drug Coatings

Appendix 2: Pre/Post Biomedical Engineering / Biotechnology Survey

This pre- and post-survey will be conducted using Google forms.

What is your gender?

What is your grade?

In what area do you believe your future career choice would be?

Math
Science
Language arts
Social sciences
Cultural arts
Sports
Other _____

Are either of your parents/guardians engineers?

Do you have any other outside experience with engineering/engineers?

Do you know the definition of engineering?

If yes, what is your definition?

List three words you associate with the term 'engineering.'

Do you know the definition of biotechnology?

If yes, what is your definition?

List three words you associate with the term 'biotechnology.'

Do you know the definition of biomedical engineering?

If yes, what is your definition?

List three words you associate with the term 'biomedical engineering.'

“Biomedical engineering (BME) is the application of **engineering** principles and design concepts to medicine and biology for healthcare purposes (e.g. diagnostic or therapeutic).” – Wikipedia In normal, everyday English, BME is the creative process resulting in something of value that solves a biomedical problem.

Given the definition of biomedical engineering, would you ever be willing to consider a career in biomedical engineering or biotechnology?

If yes, on a scale of 1-5 with 5 being the strongest and 1 being the weakest, how strong is your interest in pursuing a career in biomedical engineering or biotechnology?

Appendix 3: Survey of Biomedical Engineers

This survey will be conducted using Google forms through a biomedical engineering society.

What is your gender?

Are either of your parents/guardians engineers?

When did you first learn about engineering?

At what age did you first learn about/consider biomedical engineering as a career?

Where were you in the educational process when you first considered biomedical engineering as a career?

What was a major factor in making the decision to pursue biomedical engineering as a career?

Do you feel satisfied by your career decision?

Would you recommend a career in biomedical engineering / biotechnology?

If you were a teacher, what would you do to inspire your students to pursue a career in biomedical engineering / biotechnology?

What would you do/change about the educational process to better prepare a student for a career in biomedical engineering / biotechnology?