Research Experience for Teachers at WPI:

Bioengineering Design in the Middle School Classroom

Curriculum design process & lesson description posters 2013

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Funding: NSF EEC#1132628

Research Experience for Teachers Program:

Inquiry-Based Bioengineering Research and Design Experiences for Middle-School Teachers

Getting Students Excited about Bioengineering

Middle-school is a critical time in the education of our nation's students. In particular, there is a need to provide them with more exposure to science and engineering, and to show them how these disciplines can be used to help society. In the WPI RET program, we provide hands-on learning opportunities for middle-school teachers in bioengineering. They return to the classroom full of ideas and knowledge on how they can pass this excitement on to their students – and the confidence to teach the engineering design process, since they have done it themselves.

Bioengineering is an area that lends itself well to the design of inquiry-based learning modules. For example, teachers can learn about assistive medical devices from WPI faculty, and they may then choose to design a curriculum unit for their students on the same topic.
The teachers in this program spent 6 weeks engaged in high level bioengineering work, alongside with WPI faculty and graduate students. They also developed units for their classrooms through a collaborative process. The teachers received feedback from each other and from external mentors before presenting these units in their schools.

If you are looking for ideas about how to engage middle-school students in inquiry-based bioengineering design activities, then the lesson plans presented here will give you complete information for several interesting examples. For detailed lesson plans please see www.teachengineering.org where most of these will be published in the near future.

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P is for Pressure

Design a device and method to test the pressure in a tissue engineered bladder

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Introduction

General Description
This curriculum unit uses the Engineering Design Process to engage students in an inquiry-based, problem-solving activity in Biomedical Engineering.

Purpose
- Students need more exposure to the field of Engineering.
- Learning technology/ engineering content and skills is greatly enhanced by a hands-on, active approach. [1]
- Biomedical Engineering integrates the engineering sciences with the biomedical sciences and clinical practice [2]
- Tissue engineering combines the specialty of both engineering and biology to recreate tissues to restore lost function.[3]

Statement of Problem
Design a lesson to develop understanding of the Engineering Design Process that uses Biomedical Engineering.

Teaching Objectives and Constraints

Objectives
1. To develop knowledge of the Engineering Design Process
2. To develop knowledge of Biomedical Engineering
3. To develop problem solving skills

Constraints
- Must show evidence of the Engineering Design Process
- Must be completed in two weeks
- Must be completed with resources in the school Technology Lab (materials, work area)
- Must be designed and created in groups (design teams)

Topics Covered Engineering Design, Biomedical Engineering

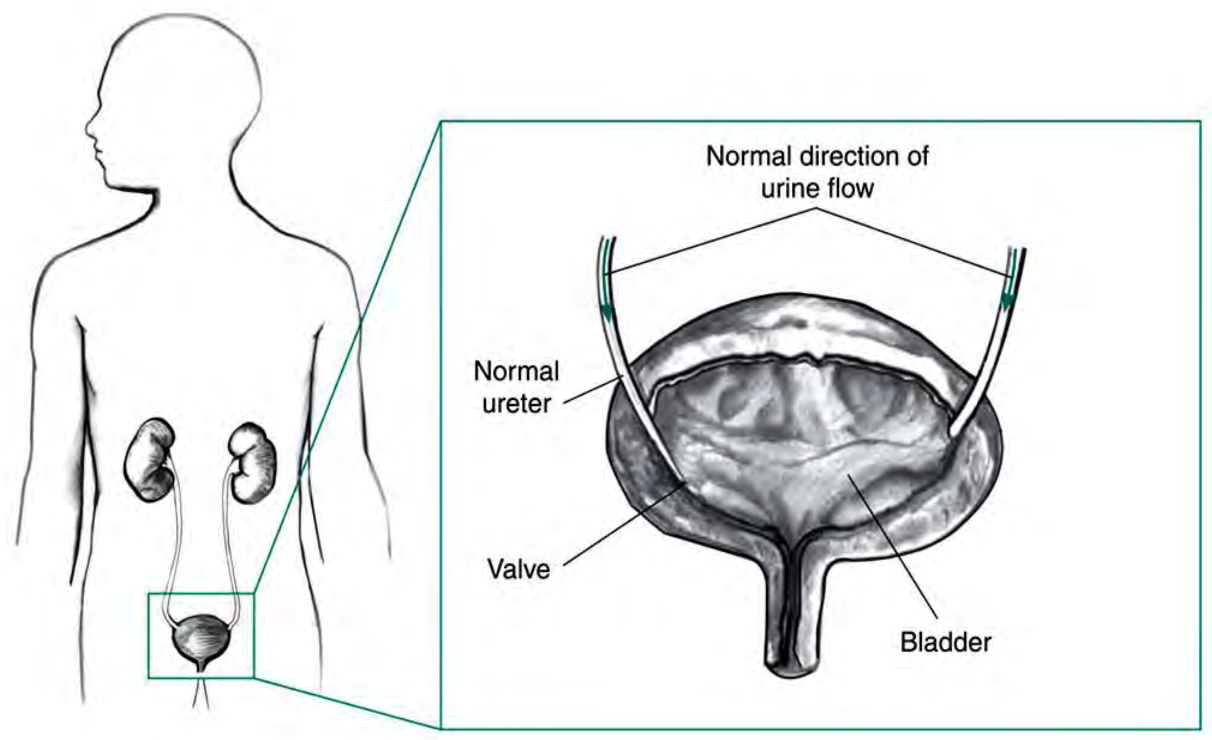
Grade Level Grade 8
Number of Students 25-35
Lesson Duration 10 classes, 50 minutes

Research/Possible Solutions

- Design a piece of exercise equipment for a person in a wheelchair
- Design a maze to act as a device for students with special needs to practice hand-eye coordination
- Design a device that helps medical professionals illuminate veins
- Design a device to test the pressure in a tissue engineered bladder
- Design a floatation device to allow a handicapped person to go swimming

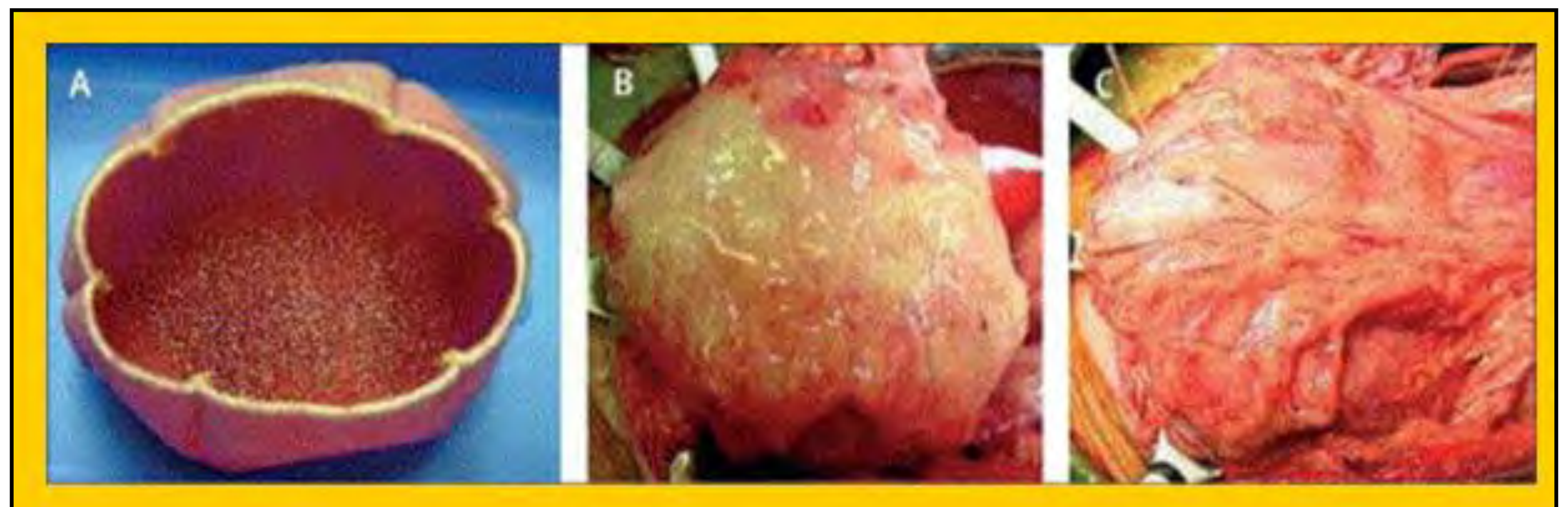
Chosen Solution

Problem Statement
Design a device and method to test the pressure in a tissue engineered bladder



https://catalog.niddk.nih.gov/imagelibrary/detail.cfm?id=1224

Objectives
1. Students will be able to solve an open-ended design problem
2. Students will be able to apply the Engineering Design Process
3. Students will be able to apply the formula for pressure



http://bme240.eng.uci.edu/students/06s/cphuang/methods.html

The engineered bladder. (A) Scaffold with cells; (B) Engineered bladder connected to bladder with sutures; (C) Implant covered with fibrin glue and omentum[4]

Constraints
1. Must be safe
2. Must cost less than $10.00
3. Must be completed in two weeks
4. Must be completed in the Technology/Engineering Lab
5. Must be designed and created in student groups (design teams)

Plan for implementation
1. Students will get instruction on the Engineering Design Process
2. Students will conduct appropriate research
3. Students will learn about objectives, constraints and functions
4. Students develop solutions and build a prototype of their design
5. Students will test their designs in class
6. Student presentations will show final designs

Assessment

Formative Assessments*
1. Informal questioning/conversation
2. Bell work
3. Exit Slips

*Used to assess knowledge of the Engineering Design Process .

Summative Assessments
1. Performance rubric- evidence of solving an open-ended design problem.
2. Final presentation- shows evidence of application of the EDP.

Conclusions/Future Work

Conclusions
- Hands-on, engaging, problem-solving activities are an effective ways to expose students to Engineering.
- Students can solve technology/engineering problems and apply scientific concepts across a wide variety of topics to develop conceptual understanding.[5]

Future
- Unit will be taught during the 2013-14 school year .
- Curriculum to be submitted to www.teachengineering.org
- Revisions to be made as needed

Acknowledgements

- Terri Camesano and Kristen Billiar- development and implementation of the RET program in Biomedical Engineering
- Jeanne Hubelbank- facilitating productive meetings and guidance on curriculum projects
- 2013 RET participants- input/feedback on curriculum and research
- National Science Foundation- grant EEC 1132628
- Rebecca Gaddis- curriculum input and supply ordering
- Mark Williams- supporting the implementation of curriculum unit

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5. Massachusetts Department of Elementary and Secondary Education Science and Technology/Engineering Curriculum Framework

Main title: LET'S GET PHYSICAL
Heart Rate Monitoring Program for Life Long Fitness

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Introduction

Problem statement:
All learning must be made relevant to the students. Additionally, students need to demonstrate their ability to apply the concepts they learn in class to real-life situations. Students spend the first 4-weeks of the school year learning measurement types, units, and proper instruments needed to achieve measure goals. The Metric system is taught as the preferred method in Science class. One field where measurements are extremely important is the medical field. When a student goes to the doctor, weight, pulse, height and blood pressure are always taken.

Engineering connections:
Additionally, students need to be introduced to the engineering design process which they will use through out the year. There are 6 engineering standards taught in 7th grade. The Engineering Design Process is a concept that need to be learned early during the year and must be mastered by the end of the school year. Student will use the engineering design process to create an exercise program that use the appropriate measurement type, unit, and tools. The program must be fun and supports a healthy heart, and will be used for a minimum of 30-60 minutes

Teaching Objectives and Constraints

Grade level: 7th -- **Numbers of students:** 4 Classes -- 112
Number/duration of class periods: 5/45 minutes
Topic covered:
- Physical Science : (Measuring matter; Measuring energy; Physical properties of Matter); Life Science (Body systems – the heart); Engineering Design Process

Curriculum objectives:
- Introduce, apply and use the steps of the Engineer Design Process;
- Convert all measurements to metric system; Analyze data and create graphs
- Use proper measurement tools and units to measure height, weight, mass, time, and temperature

Constraint:
- Parents' permission
- Class time can not exceed 45 minutes
- Cost of activity must equal $0.00
- Appropriate space to measure activities

Research/Possible Solutions

Possible Solutions – While researching these were possible solutions:
- Density project
- Design an exercise program that middle school students will use to exercise 60 minutes a day; Activity must increase the heart rate to the optimum level to support a healthy heart; student can not over exercise or under exercise
- Design an piece of equipment that middle school students with which students can exercise
- Design an exercise program for physically disabled students that they will use 60 minutes a day
- Design an exercise program that supports a healthy for elderly people in a nursing home

Chosen Solution

Problem statement:
You are a middle school student and you have read several articles that tell you that people in USA are dying from complications caused by cardiovascular conditions. In your reading you have found that exercise can prevent these problems.

http://www.ccnm.edu/be_your_best_self

You need to design an exercising program that will start and keep students exercising and monitoring their heart rate to move into life-long fitness. Remember your job is to use the appropriate measurement types, tools, and units.

Students' Objectives: – Students will be able to:
- Identify measurement types, tools, and units
- Convert to SI (metric system)
- Measure heart rate (130-160bpm)
    - Calculate maximum heart rate, resting heart rate and target heart rate
    - Record age
- Measure weight/mass and height,
- Measure pulse
- Record data in table and Create graph
- Determine the proper unit for measurement type – NO UNIT NO CREDIT!

Students' Constraints:
- Must complete all on-line lessons and homework for measurement types, tools, and units
- Must complete running the stairs model activity
- Must use metric units (meter, liter, gram)
- Must obtain parental consent to participate
- Must use the proper heart rate based on weight and height
- Must not over-exercise or under-exercise
- Must test every activity – record and graph results

Implementation: In groups of 4-5 students
- All students will be provided with an Engineer Design Process notebook
- All students must have a signed parent permission slip prior to participating in an activity
- Group must complete running the stairs model activity
- Group complete data collection and graph and turn in to teacher for approval
- Group decide which 3-4 activity to be tested
- Must obtain parental consent to participate

Assessment

Pre-EDP assessment
Post-EDP assessment
Rubric for completion of EDP notebook
Observation for testing equipment and activities
Summative:
Common Unit assessment Properties of Matter which includes measuring matter

Future Work

Increase life-science portion – circulatory
Develop program for handicapped students
Develop fitness program for nursing home residents
Increase connections between energy, work, power, calories burning (exercise) and fitness levels


http://www.dreamstime.com/stock-image-human-heart-x-ray-concept-image28737121

Acknowledgements

Terri Camesano, Ph.D. and Kristen Billiar, Ph.D, PI's
Jeanne Hubelbank, Ph.D.: Program Evaluator
Rebecca Gaddis, supply ordering
2013 RET teachers for their feedback and support
National Science Foundation: Research Funded by NSF EEC #1132628

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3. http://www.livestrong.com/article/361555-exercise-heart-rate-experiments/#ixzz2YkZuM888
4. http://www.livestrong.com/article/448974-how-long-after-working-out-does-your-heart-rate-return-to-base/#ixzz2YkaJk8PN

Form and Function of the Large Intestine

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Introduction

Integrating inquiry in science classrooms fosters academic achievement among English Language Learners[1] and can increase interest in science as a career among middle school students[2]. Using engineering as a means of facilitating science instruction is a natural fit as students learn to ask questions and develop and test their own solutions. In this activity, life science standards meet biomedical engineering as students discover how form affects function in the human body.

Problem:
Develop a lesson in which students apply the Engineering Design Process (EDP) in a hands-on activity based on the MA Life Science Standards. Students need to gain a better understanding of how form and function are related in the human body.

Teaching Objectives and Constraints

Objectives:
- Students will learn the Engineering Design Process by using it to solve a problem related to human body systems.
- Students will describe how the form and properties of human organs affect function.

Constraints:
•Limit of seven days to spend on activity
•Limit of $70 for materials for all classes
•Lesson must meet at least one MA DESE Standard for Middle School Life Science

Topics Covered: Life Science, Engineering, Biomedical Engineering
Grade Level: Grade 7
Number of Students: 60 students (20 per class) in groups of 3-4 students
Duration: Seven 50-minute class periods

Research/Possible Solutions

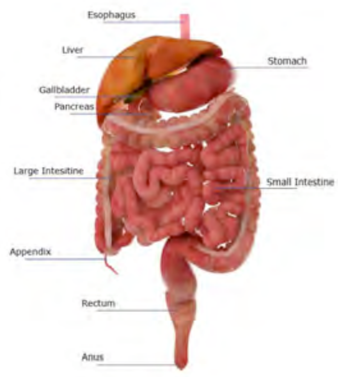
Possible Solutions:
- Design a model lung that functions similar to the human lung
- Develop a pill coating that can withstand stomach acid
- Design a functional model heart valve
- Design glasses with various filters for safely working with different types of light

Research:
- MA DESE Frameworks for Middle School Life Science
- Next Generation Science Standards
- Materials that can mimic function of intestine
- Parts of the large intestine

Chosen Solution

Problem Statement:
Develop a model large intestine that absorbs water and forms a solid as "food" travels through.

Learning Objectives:
After this lesson, students should be able to:
•Explain how the digestive system works
•Identify the function of the large intestine
•Apply each step of the Engineering Design Process to develop a functional model of the large intestine.
•Explain how the structure of the large intestine is related to its functions.
•Explain how the major body systems interact with the large intestine.



http://healthpages.org/wp-content/uploads/2011/09/digestive-system-labeled.jpg

Constraints:
•Students must work in groups of 3-4
•Model must be completed in 4 days
•Groups will have limited materials:
•3' of 1" diameter cellulose tubing; 3' of 1.25" cellulose tubing
•2' of tape

Background:
Students will be challenged to create a model large intestine that functions in the way our large intestine does. Groups will research the form and function of the large intestine and build their models accordingly. Each group will have access to a variety of materials including various lengths and diameters of cellulose tubing.

http://static.coleparmer.com/large_images/0290400.jpg

Implementation:
•Background research on the digestive system (Day 1)
•Groups develop possible solutions and submit to teacher (Day 2-3)
•Groups determine the best solution and begin constructing a prototype (Day 4-5)
•Prototypes are tested (Day 6)
•Groups prepare and submit prototype evaluation and future recommendations (Day 7)

Assessment

Formative Assessment:
- Informal check-ins with student groups throughout research, prototype construction, and testing
- Prototypes will be tested for water absorption and formation of a solid

Summative Assessment:
- Research notes on the large intestine will be collected and reviewed
- Groups' possible solutions will be turned in for approval
- Summary of prototype evaluation and future recommendations

Conclusion/Future Work

Conclusion:
Upon completion of this activity, students will be able to:
- Apply the engineering design process to other problems
- Discuss what biomedical engineers do
- Describe how the form of an object can affect its function

Future:
- Lesson will be taught to three 7th grade classes at Fuller Middle School
- Activity will be modified as needed during and after implementation
- Curriculum will be submitted to www.teachengineering.org

Acknowledgements

Special thanks to:

•Terri Camesano Ph.D. and Christopher Lambert, Ph.D.: Project mentors
•Kristen Billiar Ph.D. & Terri Camesano Ph.D.: RET program Pis
•Michelle Gallagher: Project partner
•Jeanne Hubelbank Ph.D.: Independent assessor
•National Science Foundation: Research Funded by NSF EEC #1132628

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The Hip Thing
Fabricating Custom Hip Implant Prototypes through 3D Printing

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Introduction

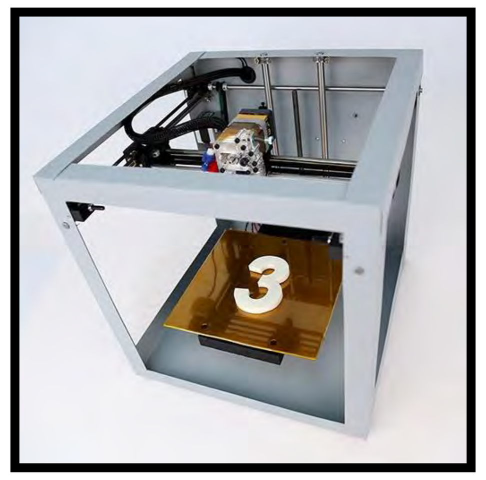
Course Description
General Science at University Park Campus School is a two-year course which serves to introduce 7th and 8th graders to a wide variety of topics. Students work in groups on inquiry and design, research, writing, community outreach, and other projects. 7th grade is generally more focused on physical and earth science; 8th grade is generally more focused on life science, but the topics are fluid.

Engineering Curriculum
This curriculum unit uses the Engineering Design Process to engage students in an inquiry-based, problem-solving activity in Biomedical Engineering. It makes use of anatomical knowledge – mainly on joints and the skeletal system – as well as the design process. The unit shows students how human-made devices can replace failed biological parts.

Statement of Problem
Create a best practices lesson in which students use the Engineering Design Process to design a device that explores the intersection of technology and human anatomy.

Teaching Objectives and Constraints

Objectives
- To increase student understanding of the Engineering Design Process
- To increase student knowledge of Biomedical Engineering
- To apply student knowledge of 3D design and printing



http://store.solidoodle.com/image/cache/data/SOLIDOODLE%20DISTORTED%20PERSPECTIVE-500x500.jpg

Constraints
- Lesson must be open-ended
- Lesson must be project-based
- Students must work in groups
- Students must use the 3D Printer
- Students must use the Engineering Design Process
- Full activity must take less than 8 class periods
- No more than one day can be spent in the computer lab

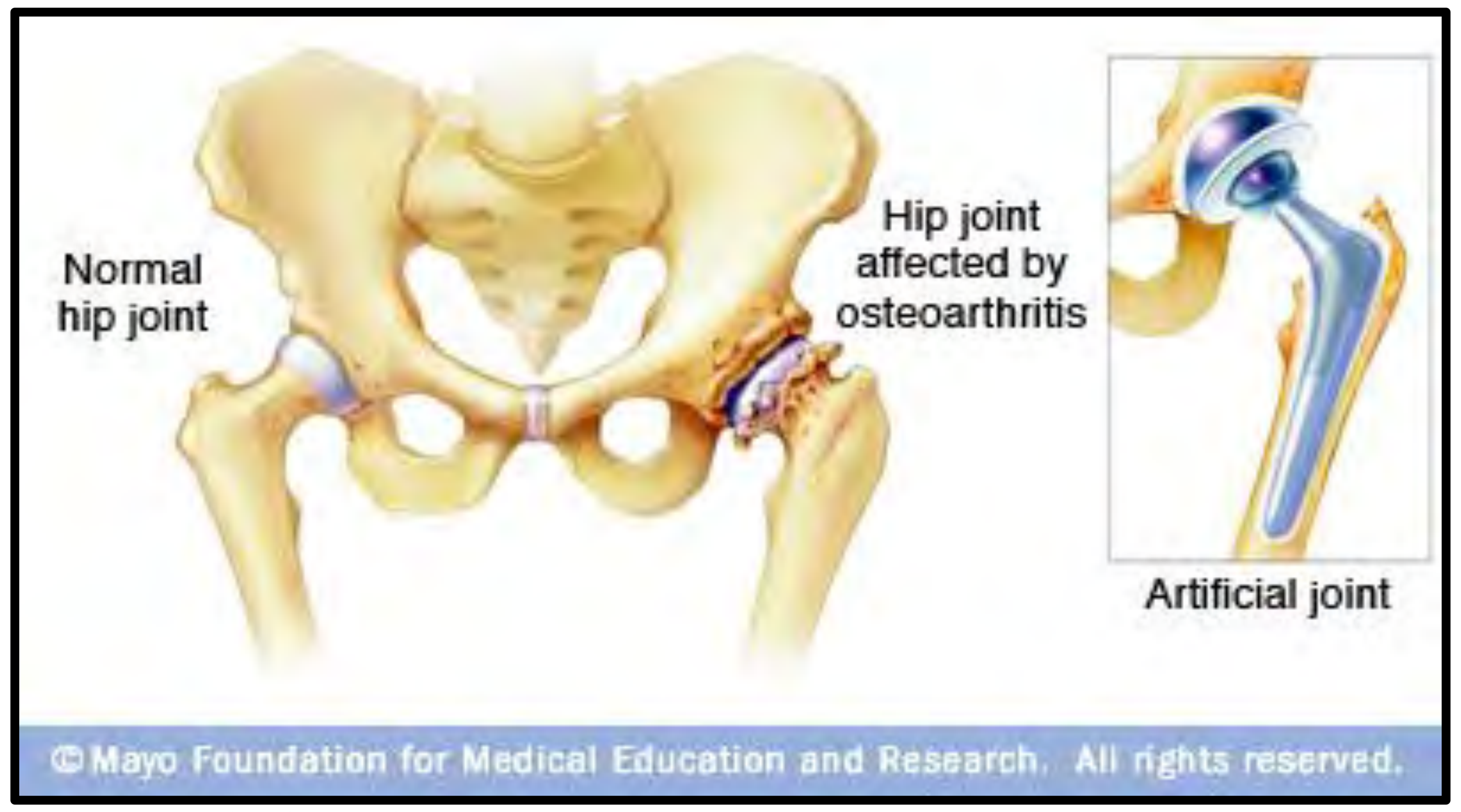
Topics Covered Using the EDP, Biomedical Engineering, Human Anatomy, Human Implant Technology

Grade Level	Grade 8
Number of Students	22-26
Lesson Duration	Five 60-minute classes

Research/Possible Solutions

- Design a custom hip implant to replace the femoral head.
- Design a custom splint for a child with a sprained finger.
- Design and print pins to hold together a fractured bone.

Chosen Solution



http://www.mayoclinic.com/images/image_popup/arth7_hipreplace.jpg

Problem Statement
Design and prototype a custom hip replacement implant based on MRI images which will fit a specific patient.

Objectives
Students will be able to:
1: Explain the characteristics and purpose of hip replacements.
2: Use the EDP to design a device based on current technology.
3: Generate accurate measurements from images.
4: Use 3D modeling software and a 3D printer to create a prototype to scale.
5: Use evidence to defend their prototype and explain design choices.

Constraints
Students must create 3 or more initial design solutions.
Chosen design must be agreed on by both partners.
Chosen design must be 3D printed in ABS plastic.
Final device must fit into the model hip.

Plan for implementation

Day 1: Students are introduced to hip replacement surgery, collaboratively decide on the most important characteristics of an implant, and begin creating their own implant designs.

Day 2: Students receive project specifications and "MRIs". Students choose their optimal design choice and find the measurements to create a prototype to scale.

Day 3: Students use their work to create a digital 3D model file in TinkerCAD which can be printed on a 3D printer.

Day 4: Students receive their printed prototypes and finalize their product by removing any scaffolding or imperfections.

Day 5: Students see how their devices fare during surgery on a model hip. Student devices are assessed on their accuracy, maneuverability, efficiency, and innovation.

Assessment

Formative Assessments
- Daily starters to uncover difficulties and misconceptions
- Uncovering prior knowledge through think-pair-shares
- Discussion-based lesson introduction
- Low-stakes preliminary writing and design

Summative Assessments
- Student measurements assessed during design
- Device's accuracy assessed through model surgery
- Student learning assessed through open-ended writing

http://upload.wikimedia.org/wikipedia/commons/2/2f/Hip_replacement_Image_3684-PH.jpg

Future Work

Conclusions
- Understanding comes from hands-on, open-ended, and multifaceted activities.
- With proper support, students can engage with legitimate problems and practices in the classroom.
- Students can and should learn with cutting-edge technologies.

Future
- Unit will be taught to 8th graders in the 2013-2014 school year.
- Curriculum will be submitted to www.teachengineering.org.
- Exploration into teaching with 3D printers will continue.

Acknowledgements

- Terri Camesano and Kristen Billiar- development and implementation of the RET program in Biomedical Engineering
- Jeanne Hubelbank- facilitating productive meetings and guidance on curriculum projects
- 2013 RET participants- input/feedback on curriculum and research
- National Science Foundation- Grant EEC 1132628
- Glenn Gaudette – Design process and coffee cup king

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American Academy of Orthopaedic Surgeons
Massachusetts Department of Elementary and Secondary Education

Wrist-Watch for the Visually Impaired: Teaching Engineering through Assistive devices and Product Design

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Introduction

Course Description: The middle school engineering program was created to teach the Massachusetts Technology standards to grades 6-8, through the use of the engineering design process in a hands-on experiential style.

Project Significance: Middle school students have been exposed to the scientific method year after year, but have had limited exposure to the engineering design process prior to the middle school engineering course. Students need to learn that there is a systematic way to address a problem and arrive at an optimal solution.

Problem Statement:
Design a teaching unit that will assist students in understanding that there are a prescribed series of steps in the engineering design process and help them gain a working knowledge of the design process as it applies to biomedical engineering. This lesson should be hands-on and empower students to take control of their own learning.

Teaching Objectives and Constraints

Grade Level: 8th (appropriate for 6-8)
Number of students: 24-30 students, arranged into groups of 3
Lesson Duration: 7class periods (55 minutes each)

Objectives/Functions:
•The module will focus on bioengineering
•The module will reinforce the students understanding of the steps involved in the engineering design process
•The module will provide the students with an opportunity to work through the engineering design process

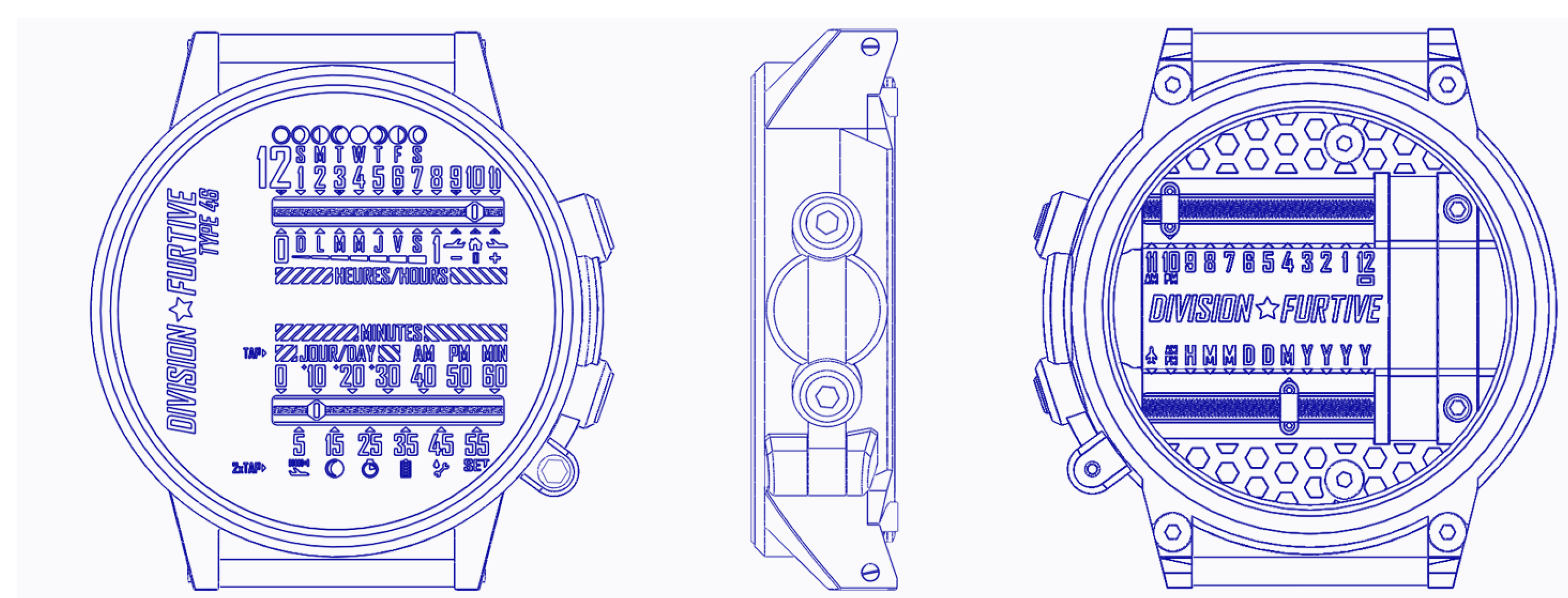
Constraints:
•The lesson must have the students utilize the engineering design process
•The module must have a duration of approximately 7 (55min.) class periods
•The module must align with the eighth grade engineering curriculum
•The module must utilize readily accessible materials and be able to be conducted in the engineering classroom

Research/Possible Solutions

1. *Bioengineering-physiology:* Design an exercise routine to maintain proper physical health for a prison inmate that has been isolated in solitary confinement.
2. *Biomedical Engineering-manufacturing*: design a shipping container that would protect fragile medical implants during shipping.
3. *Biomedical Engineering-Assistive Device*: Design a wrist-watch for a blind person.

Chosen Solution

Client Statement:
Welcome to *Dr. Time Incorporated*, the leading watch manufacturing company in New England. Our target audience has always been the young adult consumer (11-19 years old). A recent development in my own children's school has given me the idea to develop a new wrist-watch. This watch will be designed to help people with severe visual impairment. I would like you to develop this wrist-watch. Your design should fit the average 11-19 year old person, look "good," and be easy to understand. The number one goal of this product will be to help young adults with visual impairment feel more independent.



http://wornandwound.com/wp-content/uploads/2012/03/blueprint.png

Objectives:
- Design a wrist-watch for a visually impaired person
- The wrist-watch must be able to convey the time to the nearest 5 minutes without using the sense of sight
- The wrist watch must be similar in size and shape to a traditional wrist-watch and "look good" to the majority of teenagers

Testing:
Develop a three to four question survey to evaluate the effectiveness of your wrist-watch design. The survey should evaluate the visual appeal of the wrist-watch, the ease of understanding and at least one other focus area. Have five people evaluate your group's wrist-watch design

Deliverables:
- Three possible design solutions with a pro/con T-chart for each design
- Multi-view drawings of your selected safety system
- Classroom prototype
- Completed Engineering Design Process Packet
- Design presentation (3-5 min.)

http://barkingside21.blogspot.com/2008_04_01_archive.html

http://m.energize.uk.net/articles/blindpartiallysighted

http://www.thejrexperiment.com/wp-content/uploads/2013/01/blind.jpg

Assessment

•***Activity Packets***- This portion of the project will function as an assessment for the student's ability to follow the engineering design process while creating their passenger safety system.
•***Prototypes***- The student's ability to demonstrate methods of representing solutions to a design problem will be assessed with the prototypes of their designs.
•***Design Presentations***- The design presentations should include the design process, the evaluation of the design, and the future recommendations based on the data and their evaluations.

Future Plans

Conclusion: Students who complete this course should be able to…
•Utilize the engineering design process to develop a solution to the given problem
•Explain the reasons for their selected designs and material choices
•Make future recommendation based on the results of their prototype testing

Future Plans: This unit will be piloted with all eight of the engineering classes during the first trimester of the 2013/2014 school year.

Acknowledgements

Thank you to the WPI/RET faculty and staff including…
Principal Investigators: Terri Camesano, Ph.D. and Kristen Billiar, Ph.D.
Independent Assessor: Jeanne Hubelbank Ph.D.

This program was supported by an RET grant from *The National Science Foundation*
EEC# 1132628

http://www.tumblr.com/tagged/clock%20eye

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Burn After Eating

Constructing a Calorimeter for Calorie Counting

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Introduction

Course Description: The 8th grade Chemistry curriculum at the Advanced Math and Science Academy is geared to practical application. The course is provides a foundation for Chemistry and describes major topics that will be used to further a student's knowledge about physical science. This course allows the students to see how Chemistry is implemented in every day life and how it is used to make the world more efficient.

Linking to Engineering: The goal of this project is to encourage students to identify and solve a problem. Students will use the engineering design process to find multiple solutions to a problem, then pick a solution they think is the best to solve a given problem. Allowing the students to use this type of inquiry learning will enable them to become better critical thinkers.

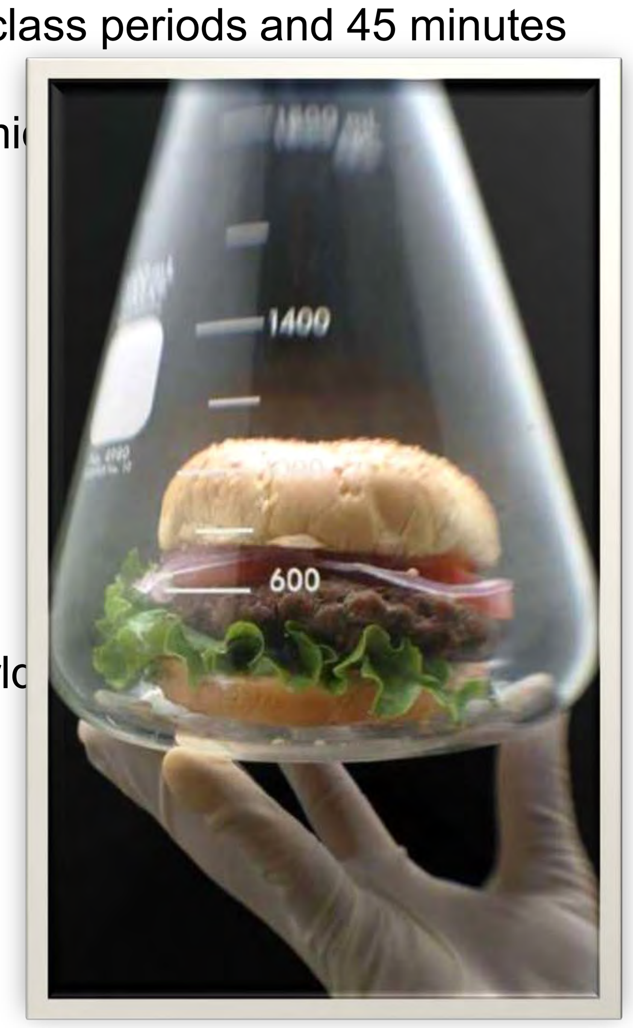
Problem Statement: To design a lesson that shows the practical application of thermodynamics. This lesson must address the topics of thermodynamics by explaining heat flow, calorimetry, using mathematical equations to gather data and relating this to real world application (e.g. metabolism).

Teaching Objectives and Constraints

Grade level: 8th and10th grade
Numbers of students: Max 24 students
Number and duration of class periods: 4 class periods and 45 minutes each class
Topics covered: Metabolism, Thermodynami and Calorimetry

Curriculum Objectives:
- Connect to 8th grade science curriculum
- Learn about the engineering design process
- Learn to problem solve
- Use math equations to analyze data
- Understand the different units of energy
- Investigate how science relates to real worlc
- application

Constraints:
- Maximum of 24 students
- Size and functionality of classroom
- Number of class periods spent on topic
- Limited resources and maximum of $10 per calorimeter.



http://articles.latimes.com/2013/mar/15/news/la-dd-ucla-science-and-food-2013-lecture-series-lineup-announced-20130315

Research/Possible Solutions

1. Cooling apparatus for paralyzed person : Students will design an apparatus to keep a person who is paralyzed cool in hot environments.
2. Warming a person who has poor circulation: Students will design a devise that will keep an elderly or person with poor circulation warm. Students will focus on a person's extremities to keep warm.
3. Medical heating or cooling: Students will design a storage/delivery device that will be used to store temperature sensitive medical equipment for an extended period of time..
4. Constructing a calorie counter: Students will construct a device that will be used to determine the amount of energy or calories present in a specific type of food.

Chosen Solution

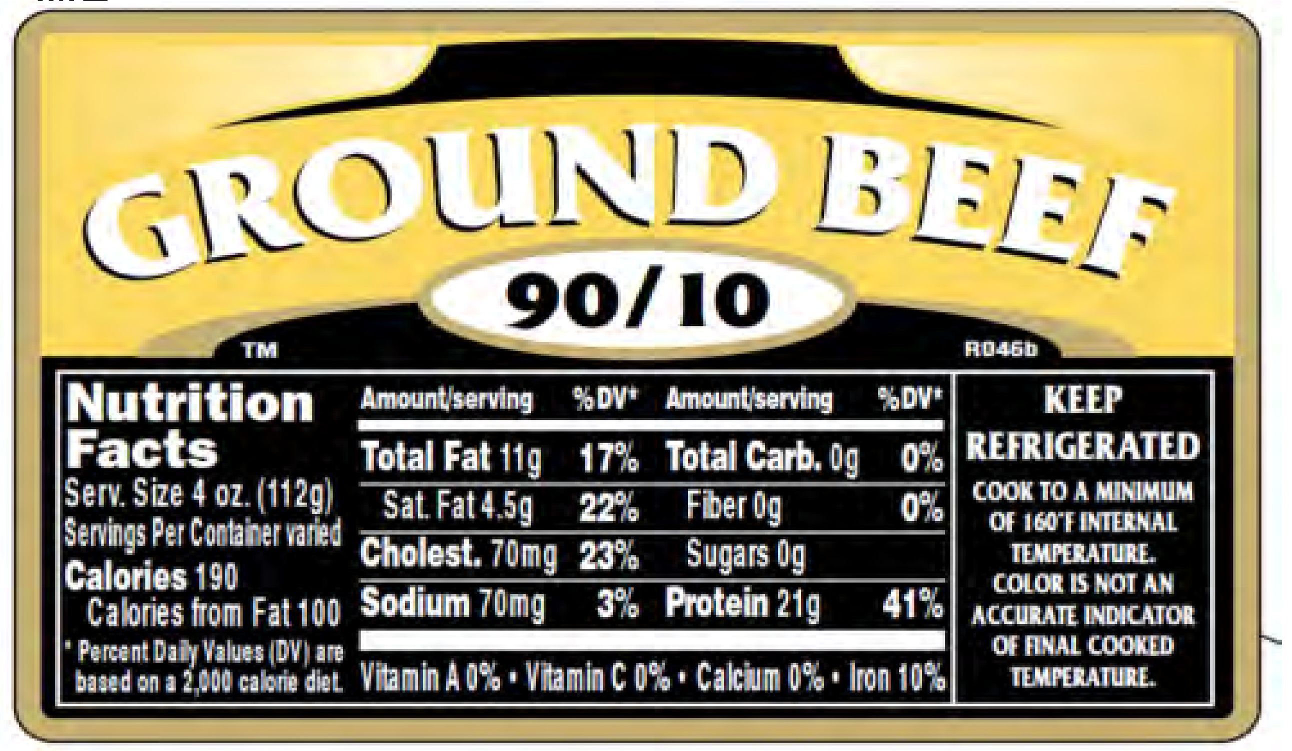
- **Client Statement**: You are an analyst at the Food and Drug Administration (FDA) and your job title is to the analyze the amount of calories in particular amounts of food. Your assignment is to construct a device that can be used to determine the amount of calories in popular consumed food in a high school cafeteria. The device you construct must accurately determine the amount of calories, be reusable, and make readily available materials.

Learning Objectives:
Students will be able to:
- •Explain the characteristics of thermodynamics and heat flow
- •Describe connections between calorimetry and the human metabolism
- •Use their calorimeter to model the human metabolism
- •Explain how a calorimeter works
- •Use an $q=mc\Delta T$ equation to calculate the amount of calories in a given amount of food
- • Use the engineering design process to construct an efficient calorimeter

Constraints:
- Calorimeter must be made of readily available materials
- Calorimeter has to be able to hold diverse types of food
- Calorimeter must be flame retardant
- Calorimeter must be reusable
- Students only have four class periods to research, design, test and retest

Implementation:
- Students will learn how a calorimeter works and how it can be used to calculate the amount of calories in food
- Students will work in groups to come up with multiple designs for their calorimeter
- Each group will receive a different type of food (i.e., Carbohydrate, Sugar or Fat/Lipid)
- Each group will get two chances to test/redesign their prototype, before they have to do a formal test for accuracy of their calorimeter
- Each group will fill out a worksheet about the whole process and

http://www.arborsci.com/cool/introducing-energy-with-the-learning-cycle



http://www.foodpolitics.com/tag/labels/page/4/

Assessment

- •Teacher will daily check the stage of the project and give full participation grade for each productive day of work.
- •Students will receive a pre- and post- assessment on the engineering design process, constructed by RET program.
- •Students will be required to fill out a worksheet detailing both the engineering and design process and concept of calorimetry .
- • Students will take a quiz on the topics that are covered in this project
- •Each group will receive a grade on their prototype design and how they altered their prototype to make it better at addressing the problem.
- •Each will also be graded on how well their final artifact addresses the client statement.

Future Work

- • Lesson will be taught during the 3rd term.
- •Results will be reported to WPI and TeachEngineering.com after lesson is implemented.
- •Results reported to WPI and RET program when date is announced .
- •Proper alterations to lesson that are requested by Teach Engineer.

Acknowledgements

•RET Programs/WPI
•Terri Camesano Ph.D., Kristen Billiar Ph.D., Jeanne Hubelbank Ph. D.
•My Project Partner: Jared Quinn
•Project Mentors: George Pins, Ph.D. and Jonathan M. Grasman
•Funded by National Science Foundation (EEC# 1132628)

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- http://www.youtube.com/watch?v=Ak7PN8tn4cU
- http://www.phy.duke.edu/~rgb/Class/phy51/phy51/node59.html
- http://www.wiley.com/college/trefil/0470118547/vdl/lab_calorimeter
- http://www.youtube.com/watch?v=Mryi1xY8IcA

Is it getting hard to breathe in here… or is it just me?

Michelle Gallagher
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Introduction

Everybody breathes. All day, every day. Why? When you breathe, you are allowing your body to intake oxygen and pass it throughout your body, through a process known as cellular respiration. What do you think would happen if this function of our life, breathing, was hindered? How much oxygen can our lungs hold and can outside stimuli affect it? Can we measure how much oxygen our lungs can hold? Is there another function in our body that could take over and allow us to survive?

Problem Statement:

Students will research, demonstrate, collect data and compare the effects that viruses and asthma have on lung capacity by measuring respiration before the simulation of an asthma or viral attack and after a viral attack on the respiratory system.

Teaching Objectives and Constraints

Objectives:
- To increase student understanding of the Engineering Design Process
- To increase student knowledge of Biomedical Engineering
- To increase student problem solving skills

Constraints:
- Class time is limited to 55 minute classes
- Must meet the Massachusetts Science and Technology Standards
- Unit cannot exceed 10 class periods
- Materials and cost cannot exceed $10

Topics covered: Physical Science, Life Science, Science Inquiry, and Technology & Engineering

Student grade: 8th
Number of students: 20 to 24 per class working in groups of 4 to 5
Lesson duration: 7-9 55 minute class periods

Research/Possible Solutions

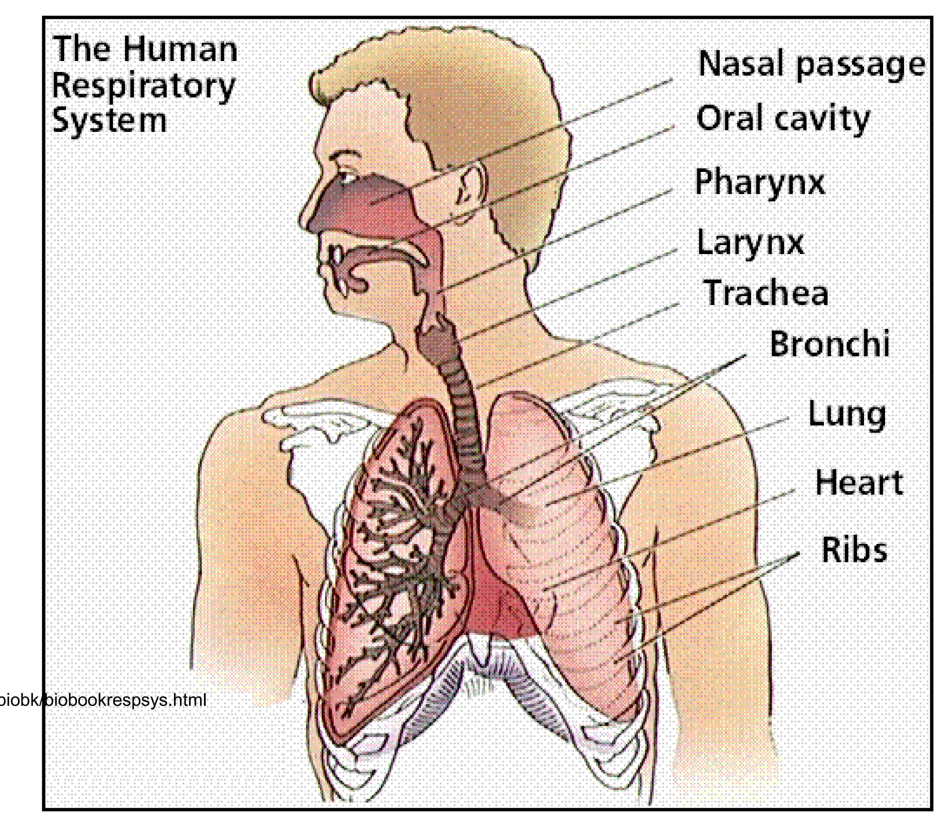
Possible Solutions:
While developing this unit, the following possible solutions were considered:
- Create a mask that would filter out the toxins and would affect the respiration process therefore affecting lung capacity
- Researching the affect of different viruses on the lungs and the most harmful irritants to the respiratory system
- Using the Engineering Design Process to create an effective way to measure lung capacity

Research Solutions (for students):
- Research the respiratory system and how the lungs function under normal circumstances and how outside stimuli affect the way the way they may function
- Research how spirometers work and the rates of oxygen needed in the lungs
- Research the supplies needed to make a homemade spirometer

Chosen Solution

Students will take part in the "Is it getting hard to breathe in here…or is it just me?" unit as both the scientist and as the engineer.. Students will demonstrate an understanding by:

- Comparing and contrasting the similarities and differences between the scientific method and the engineering design process by creating a five paragraph essay.
- Reinforcing core curriculum concepts and math literacy topics while working through a design problem based on a current unit of study
- Investigating how bioengineering technologies are used to design and construct devices to monitor health



http://www.emc.maricopa.edu/faculty/farabee/biobk/biobookrespsys.html

Objectives:
Students will
- Research the respiratory system and the effect viruses and outside stimuli have on it
- Students will apply the Engineering Design Process to solve a problem
- Students will develop multiple solutions to the problem

Constraints:
Project must be:
- Designed and completed by groups of 4 or 5 students in 7-10 class periods
- Must use only the supplies given on the table in the front of the room
- All members of the group must be able to work the device and explain how it functions
- Device must be able to measure lung capacity within 5-10ml of store bought spirometer

Implementation of lesson:
Students will:
- receive instruction on the Engineering Design Process
- conduct appropriate research
- work in groups to carry out the steps of the Engineering Design Process
- build a prototype and will test their designs in class
- present their final designs and communicate their learning

Assessment

Formative Assessment:
- Demonstration of prototype to show it in functioning order
- Pretest and post test assessment
- Frequent check-in to monitor progress of prototype, providing assistance and/or redirection when needed

Summative Assessment:
- Evaluation of students' final design solutions to assess level of mastery of the Engineering Design Process
- Project reflection to verify evidence of learning the objectives listed
- Demonstration comparison of the store bought spirometer and the group manufactured spirometer within 5-10ml by each member of the group

Future Work

Conclusions:
Students will:
- engage in hands on problem-solving activities collaboratively
- use the engineering design process to test a biological process
- research a body system and outside factors that can affect the system from normal every day functions

Future:
Unit will be:
- taught during the 2013-2014 school year and feedback will be reported in the spring of 2014
- modified, as needed, to meet the needs of the students and allow them to have a complete understanding of the learning objectives
- submitted to www.teachengineering.org

Acknowledgements

Terri Camesano, Ph.D. and Kristen Billiar, Ph.D, PI's
Jeanne Hubelbank, Ph.D.: Program Evaluator
Rebecca Gaddis, supply ordering
RET co-teachers for their feedback week after week.
National Science Foundation: Research Funded by NSF EEC #1132628

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Keep Cool and Ship Safe

Design of a package to maintain the temperature of a blood sample during shipping

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Introduction

Background

- Engineers improve human life by solving problems.
- Students need more exposure to the field of Engineering.
- Learning technology/ engineering content and skills are greatly enhanced by a hands-on, active approach.

Biomedical Engineering:

- Improves human health through cross-disciplinary activities
- Integrates the engineering sciences with the biomedical sciences and clinical practice

General Description

This curriculum unit uses the Engineering Design Process to engage students in an inquiry-based, problem-solving activity in Biomedical Engineering.

Statement of Problem

Design a lesson that will use the engineering design process to solve a relevant biomedical engineering problem faced today. Using hands-on project based lesson to teach students of varying learning abilities how to compare different materials to select the most appropriate options for their design

Teaching Objectives and Constraints

Objectives

- To have student practice using the Engineering Design Process
- To increase student exposure to Biomedical Engineering
- To have students maximize effectiveness of design through materials selection

Constraints

- Must work in space with no more than 1 cubic foot of storage per team of 2 students
- Time: no more than 12 days on project

Topics Covered

Engineering Design, Biomedical Engineering

http://goneforgoodstore.com/

Grade Level	Grade 7
Number of Students	16-24
Lesson Duration	12 classes, 45 minutes

Research/Possible Solutions

- Ship a blood sample in a temperature stable container
- Develop a waterproof enclosure for an event recorder
- Create an emergency kit for boat problems at sea

http://gardengs.com/hot-and-cold-pack/

Chosen Solution

http://ansciproducts.com/images/productimages/Two-Vial-Mailer.jpg

Problem Statement

Use the engineering design process to solve a relevant biomedical engineering problem faced today. Specifically, create a temperature stable container to ship a blood sample.

Learning objectives … students will

1. Correctly identify the steps of the engineering design process in order.
2. Apply their knowledge of the design process to solve an open-ended problem.
3. Articulate the reasons for their materials choice using criteria such as cost, size, and properties.
4. Test their designs
5. Modify their designs based on problems they have identified during testing.

Blood Donation Process

http://www.redcrossblood.org/learn-about-blood/what-happens-donated-blood

Constraints

- Must develop three possible designs
- Must conduct multiple tests with increasing time durations
- Must be completed in 12 days
- Must be completed in the Technology/Engineering Lab
- Must be designed and created in student groups (design teams)
- Chosen solution must be safe
- Chosen solution must be smaller that 12 x 12 x 12 inches
- Chosen solution must weigh less than 10 pounds
- Chosen solution must maintain internal temperature within a 10°F window for 24 hours

Plan for implementation - Students will

1. Receive instruction on the Engineering Design Process
2. Conduct appropriate research
3. Learn about objectives, constraints and functions
4. Develop solutions and build a prototype of their design
5. Test their designs in class
6. Present their final designs
7. Explain their choices of materials

Assessment

https://www.usaemergencysupply.com

Formative Assessments

1. Pre test designed by RET cohort
2. Bell work
3. Exit Slips

These are used to assess knowledge of the Engineering Design Process (EDP).

Summative Assessments

1. Post test designed by RET cohort
2. Completion of project- indicates application of the EDP
3. Final presentation- shows evidence of using the EDP including multiple design solutions and communication of design solution

Future Work

Conclusions

- Students need engaging, hands on problem-solving activities.
- Students can solve technology/engineering problems and apply scientific concepts across a wide variety of topics to develop conceptual understanding

Future

- Unit will be taught during the 2013-14 school year
- Curriculum to be submitted to www.teachengineering.org
- Revisions to be made as needed

Acknowledgements

- Terri Camesano and Kristen Billiar- development and implementation of the RET program in Biomedical Engineering
- Jeanne Hubelbank- facilitation of meetings and guidance on curriculum projects
- 2012 RET participants- input/feedback on curriculum and research
- National Science Foundation- grant EEC 1132628
- Rebecca Gaddis- curriculum input and supply ordering
- Glenn Gaudette and Katrina Hansen for their guidance and patience

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Massachusetts Department of Elementary and Secondary Education Science and Technology/Engineering Curriculum Framework

Next Generation Science Standards