Research Experience for Teachers at WPI:

Bioengineering Design in the Middle School Classroom

Curriculum design process & lesson description posters 2012

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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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Meal Time With Friends
Developing Solutions Though Experience

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Introduction

Problem:
•Create a curriculum unit to teach the Engineering Design Process (EDP) through experiential learning
•Introduce structure to the ways students approach solving problems

General Description:
Engineering is a hands on enterprise that allows us to change the word around us. The EDP is a process that approaches a problem in a structured way, and can be utilized in the classroom by the students.

Purpose:
•Give students hands on introduction to using the EDP
•Explore biomedical engineering though the development of assistive devices
•Exposure students to the field of Engineering

Teaching Objectives and Constraints

Objectives:
•To create an enduring understanding of the engineering design process (EDP) for the students by having them use it to solve a problem they have experienced first hand.
•Build on our character education program by having the students experience a physical limitation so they can better understand the needs of others, and in the process foster empathy and reflection.

Constraints:
- Students will be limited to supplies available in the classroom
- Must meet DESE standards for science and technology and fit in the curriculum time line
- Students have incomplete background knowledge in technology and engineering
- Project must be completed in groups

Topics covered: Technology/Engineering, Life Science, Physical Science
Student Grade: 7th grade Technology/ Engineering
Number of students: 120 students (24 per class) in groups of 3-4
Duration: 20 class periods, 50 minutes

Research/Possible Solutions

Possible Solutions Considered:
- Build a replica of an arm with two working joints to better understand the muscular skeletal system
- Create a cast for a broken finger that will help speed healing
- Adopt a garden tool for a person with reduced grip /missing fingers
- Design a living wall that would clean the air in our classroom
- Develop a device to help with preparing ,eating ,or cleaning up after a meal for someone with decreased dexterity in their hands

Chosen Solution

Problem Statement:
Develop a device that makes eating and preparing food more manageable for someone with hand injuries or limited dexterity in their hand

Objectives: Students will be able:
- To list the steps of the engineering design process
- To create multiple design solutions to a problem
- To define and explain the purpose of Biomedical Engineering
- Make and test a prototype to solve their open ended problem

Constraints: Students will:
- Have limited time
- Work in groups
- Access to limited materials


http://www.buyopensesame.com/img/bigsample.jpg

Students will be given materials that limit their ability to use their hands as effectively as they are used to. The reason for this will be to give them experience similar to someone who has limited dexterity, or has a hand injury. And by eating a meal this way they will be able to identify the difficulties they need to design solutions for. Each group will have a different disability they experience during the meal

Deliverables:
3 design solutions with pro con list and picture for each solution
Completed EDP guided brainstorming sheet
Poster presentation outlining the steps of the design process and what they did in each step
3 recommendations and picture for possible redesigns
Completed prototype that meets the needs they have identified


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Assessment

Formative Assessment:
- EDP speed quiz
- Exit slips/ Entrance questions

Summative Assessment:
- Poster showing the steps of the EDP and specifically their process
- Test on stages of the EDP
- EDP workbook completed to teacher specifications

Testing your solution against your objectives


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Possible Pitfalls and Alternatives

Unit will be modified as needed to further meet the needs of students and learning objectives

Conclusions:
Students retain information more effectively from hands on and inquiry learning
Upon completion of the unit students should be able to:
- Define biomedical engineering
- Use the steps of the EDP effectively solve a Problem

Future:
- Unit will be taught during the upcoming year at AKFCS, results will follow
- Curriculum will be submitted to www.teachengineering.org

Acknowledgements

I would like to thank Allen Hoffman, Ph.D, Terri Camesano, Ph.D, and Kristen Billiar, Ph.D, for their mentorship in the engineering and design process.

A special thanks to Michelle Gallagher my Project partner and to Jeanne Hubelbank, Ph.D for her help with curriculum formation and assessment.

All of the 2012 RET participants for their help and feedback

This program was supported by grant number EEC1132628 from the National Science Foundation

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The Role of Surfactants on the Lung

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Introduction

Overview of problem:

1. Students need to experience an application of the engineering design process
2. There is a lack of interest and enthusiasm in applied science/ mathematics
3. Science curriculum often lacks creative methods for making connections between science, medicine, and engineering

In this unit…

1. Activities and discussions will assist students in understanding how surface tension affects respiration and alveolar function
2. Students apply the steps of the engineering design process to develop an effective method for measuring surface tension

Teaching Objectives and Constraints

Problem Statement: Students need to learn a curriculum unit that covers an aspect of biomedical engineering. The unit should support the Massachusetts Science and Technology/Engineering frameworks.
Objectives: After completing this unit, the students will be able to:

1. Explain how surfactants affect surface tension
2. Understand the steps of the engineering design process
3. Describe how surface tension can be measured

Constraints:

1. Time
2. Materials
3. Diverse learning groups
4. Cost

Topics covered: technology, engineering, physical science
Student grade: 7th
Numbers of students: 24 per class
Number and duration of class periods: 10 periods, 45 min/class

Research/Possible Solutions

Possible Solutions:

1. Design a tubular scaffold that can be used to grow/engineer blood vessels
2. Design and construct a prosthetic heart valve
3. Design and construct a seat belt harness for a 5-6 year old child
4. Design a vehicle with modifications for a disabled person
5. Create a device that accurately measures surface tension– Best meets objectives and constraints

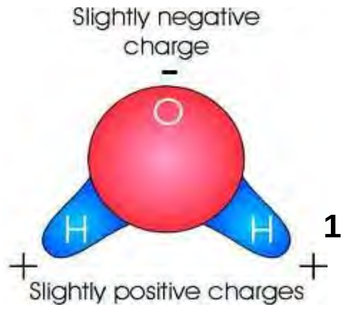
The chosen solution best supports the science content and curriculum that the students investigate in the 7th grade.

Chosen Solution

Problem Statement:
Design and build a device that accurately measures surface tension. The device should be able to quantify the surface tension of various liquids.

Constraints: The device should:

1. Give a measurement using a number
2. Be durable
3. Be constructed from materials provided by your teacher
4. Have the ability to test at least three different liquids
5. Give reliable measurements (maximum 30% difference between measurements of a specific liquid)



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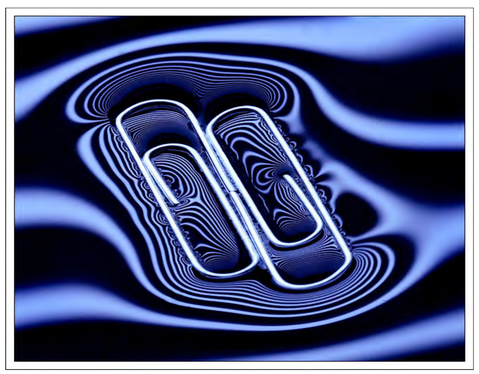
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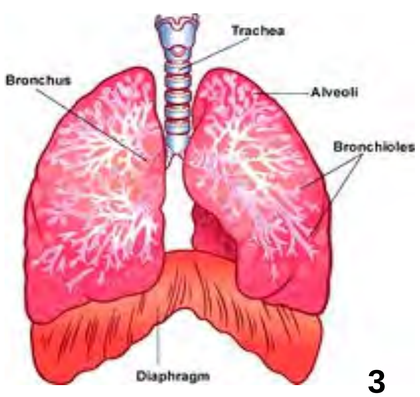
Students will:

1. Work in groups of two
2. Relate engineering to character education
3. Create sketches, orthographic projections, and multiview drawings
4. Understand how surfactants and surface tension affect lung function
5. Gain exposure to chemistry and measurement systems by working with physical properties of water

The teacher will:

1. Emphasize trade-offs and redesign so students understand the application of the engineering design process
2. Encourage students to relate various chemistry concepts to biomedical engineering
3. Explain the importance of measurement devices in the fields of science and medicine



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Assessment

The teacher will determine if the students' projects demonstrate understanding and comprehension of:

1. Surface tension
2. The engineering design process
3. The importance of measurement in science

The following types of assessment will be used:

1. Participation in discussions and related class activities
2. Project presentations
3. Written response that includes:
   - Details on how they have demonstrated each step of the engineering design process
   - A summary of lung function and how it relates to surface tension and surfactants

Future Work

1. Ask students to share examples of surface tension from their lives

2. Students can brainstorm the significance of biomedical engineering by bringing in literature or articles that relate to the field

3. Have students create a written response that explains the importance of the character virtues in the field of engineering

Extension Activities:

1. Build a model of the lungs and/or alveoli and demonstrate how surfactants affect respiration
2. Further investigate surface tension by using the contact angle measurement method
3. Create a multimedia presentation that shows how biomedical engineering impacts our lives and society

Acknowledgements

Raymond Page, PhD
Terri Camesano, PhD
Kris Billiar, PhD
Jeanne Hubelbank, PhD
Jason Forte

NSF grant EEC 1132628

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Will a mask protect me from cold air?

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Introduction

Students have great difficulty understanding the functions of different systems of the human body. Therefore, misconceptions can occur and delay the learning process.

Problem statement: Develop a curriculum module based on the Massachusetts Department of Elementary and Secondary Education frameworks, which requires the students to learn general functions of the major systems of the human body. This module will incorporate Bioengineering and the use of the Engineering Design Process to deepen students knowledge on the respiratory system and respiratory problems.

Illustration 1 - Microsoft Clipart

Teaching Objectives and Constraints

Objectives:
- Learn about organ systems and their functions
- Understand the functions of the lungs
- Apply the Engineering Design Process to design and construct a mask to keep cold air away from nose and mouth

Constraints
- Must be completed with resources in the classroom
- Must be designed and created to help students to develop English language acquisition
- Must fit into Massachusetts Science and Technology standards

Topics covered: Systems of the human body, Engineering Design Process
Student grade – 7th grade
Number and duration of class periods: 7 x 48 min (classroom)

Research/Possible Solutions

1st option: Students will design and build a filter to mimic the function of the liver
2ndoption: The students are asked to design an artificial organ system which will work as one. Students can replicate their artificial organ system using an array of materials
3rd option: Students will design and build a protective device to control temperatures changes that affect breathing (mask) for a person with lungs (respiratory) problems
4th option: Students will prove that CPR/Defibrillator can be helpful to resuscitate a patient

Chosen Solution

Illustration 2 - Microsoft Clipart

- **Objective:** Using the Engineering Design Process students will design and construct a mask to control temperatures changes that affect breathing for a person with respiratory disease (asthma and bronchitis) to better describe the functions of the lungs.

- **Constraints:**
✓Work in groups
✓ Use the following materials: fleece, cotton balls, yarn, cloth, elastic band, aluminum foil, felt, paper towels, glue
✓Students should use only three items of the list
✓ The mask should be able to keep winter/cold air away from the nose and mouth of the patient. It should also increase the outside temperature on a minimum of 10˚ to the inside the mask
- **Testing:**
✓The students will go outside on a cold day and use digital temperature measuring device to determine the efficiency of the mask.

- **Lesson development:**
Step 1: Using the Engineering Design Process to come up with at least 3 possible solutions for the mask. With the help of the teacher choose one of the possible proposals and write a brief explanation of how each material will work to obtain the best results. Draw and label the parts of your mask, explaining the purpose of each part.
Step 2: Submit your project explanation and illustration to the teacher. These will be checked for design originality and thoroughness in applying unit concepts during the planning of the mask.
Step 3: Making the prototype
Step 4: Testing the prototype
Step 5: Redesign
Step 6: Test again
Step 7: Communicate the best solution to the teacher and classmates.

Students at work

Assessment

Formative Assessment
•Student/teacher will make regular checks during group work
•Daily journal entry

Summative Assessment
• Group final presentations
•The written part of the project
•Pre and post assessment on the Engineering Design Process

The prototype of the mask will be assessed on:
✓How well the mask keeps the cold air from nose and mouth
✓Change in temperature equal to or greater than 10˚
✓Innovative design

Future Work

Conclusions will be formed post lesson and unit will be changed as needed
Adaptations are expected and will be welcomed
This lesson unites curriculum standards with real life situations
This lesson will be submitted to teachengineering.org website

Acknowledgements

•Special thanks to the RET – WPI Professors and presenters
•Terri Camesano, Kristen Billiar, Jeanne Hubelbank and Rebecca Gaddis
•To the RET-2012 teachers and especially to my project partner Thomas Oliva
• Project Mentors – Glenn R. Gaudette, George D. Pins
•Graduate Students – John Favreau and Jonathan M. Grasman
• Funded by the National Science Foundation (EEC# 1132628)

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Engineering and Earth Science: Is Your Cell Phone Safe?

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Introduction

The Purpose of "Is Your Cell Phone Safe?" lesson is to demonstrate that earth science concepts such as electro magnetic fields (EMF) apply to other disciplines such as biomedical engineering. EMF are created in Earth's interior and also by electronic devices such as cell phones. Today, many students own cell phones and cell phones' EMF can be harmful to people. Therefore students will create a cell phone shield using the engineering design process.

Problem Statement: Design a lesson that will help students understand and apply the steps of the engineering design process as it relates to both Massachusetts Frameworks for Earth Science and Biomedical Engineering.

Teaching Objectives and Constraints

Grade Level: 6th (6-8)
Number of Students: 24- 28 organized into groups of 3-4.
Lesson Duration: 10 class periods, each 55 minutes long.
Objectives:
- Help students develop an understanding of how to apply the steps of the engineering design process.
- Introduce students to problems solving skills.
- Introduce students to biomedical engineering.

Constraints:
- Students do not have much if any experience working on design open ended problems.
- Students have a minimal science background.
- Students have little to no background in engineering.

Topics Covered:
Earth Science and Technology and Engineering

http://cellphones.procon.org/

Research/Possible Solutions

In developing this lesson the following solutions to the problem were studied:
•Build a tether prototype to act as a model for a future space elevator.
•Build an exercise device that can be used in microgravity to help astronauts retain muscle mass on extended space missions.
•Create a shielding device for cell phones in order to protect people from potentially harmful electro magnetic fields.

Chosen Solution

Solution: Create a shielding device for cell phones in order to protect people from potentially harmful electro magnetic fields.

Client Statement: Design a shield to protect people from harmful EMF created by cell phones.

Objectives:
- Apply the steps of the engineering design process.
- Draw what an electro magnetic field looks like.
- Explain how cell phones can be dangerous to people.
- Describe how a cell phone's magnetic field can be measured.
- Use an EMF (Gauss Meter).
- Make a prototype of a cell phone shield.

Constraints:
- Use only the materials provided by the teacher.
- No more than 15cm X 15cm of any one material may be used in the design.
- Complete design by working in small groups.
- Shield must be functional and marketable.
- Time: design completed in 5 class periods.

Topics Covered:
Earth Science and Technology, and Biomedical Engineering

http://img.timeinc.net/time/daily2010/1003a_ICellphone_0315.jpg

Execution of Solution:
Conduct pre design lessons:
- Visualizing magnetic fields using permanent magnets, electro magnets, and iron filings.
- Learn to use a Gauss Meter to obtain electro magnetic field strengths by testing various electronic devices.
- Conduct research on electro magnetic fields and what kinds of materials make good shields against electro magnetic fields.

Conduct Design:
- Give students Engineering Design Process Guide and Problem/Client Statement.
- Guide students through the engineering design process as they work through the EDP Guide to design, build, and test their prototype shield.

Assessment

Formative Assessment:
- Check in with each group periodically to ensure they are following the "Engineering Design Process Guide."

Summative Assessment:
- Grade student completed copies of the "Engineering Design Process Guide" for reasoning, testing results and reflection of design.
- Quantify students' designs by Gauss meter reading from testing. Goal:cell phones emit less than 3mG units when in use with shield prototype.

Future Work

Upon completion of the lesson students should be able to:
Explain how the engineering design process works.
Describe what an electromagnetic field looks like.
Provide details on how to prevent harm to people from EMF.

Future:
- Curriculum will be submitted to teachengineering.org
- Will teach lesson in 2012/2013 school year.
- Lesson will be modified in the future to meet student needs in order to obtain learning objectives.

Acknowledgements

Special thanks to: Project mentors Terri Camesano, PH.D and Ivan Ivanov.

Thank you to: Curriculum and Assessment advisors Kris Billiar, PH.D, Jeanne Hubelbank, PH.D. and Robin Belisle, project associate.

The program was funded by NSF: EEC#1132628.

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Can it Support You?: No Bones About It

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Introduction

General Description

- Students struggle with the concept of density. Without this concept, it is difficult to teach the rest of the curriculum. Especially because this is one of the first concepts taught.

- Bone structure is important to our daily life. It allows us to stand, to move and to support ourselves. But what if our bones were brittle? What if our bones were solid? The density of our bones is extremely important. The students are to research the density of human bones and find alternative or substitute bone structures.

Statement of Problem

- Design a unit to develop the hands-on understanding of density and the engineering design process that uses Biomedical Engineering.

Teaching Objectives and Constraints

Objectives

- For students to be proficient using the engineering design process
- For students to calculate density
- For students to explain the concept of density.
- For students to communicate to the class their findings.

Constraints

- Must be completed with resources given; laminate, woods, metals…
- Must be done within the 9-10 class periods provided
- Triple beam balances being used may not be calibrated correctly
- Must be done during "Lit Lab" enrichment classes. (30 minute classes)
- Technology access is not always reliable.
- Must fit into Massachusetts core curriculum standards.
- Mixed class of grade 7 and 8th grade students.
- Class of 20 students
- Students will work in groups of 4
- Cost of the project is limited to recycled supplies found within the lab

Research/Possible Solutions

Possible Solutions:

- Students learn how organisms float, sink, or hover in water as they construct a equally buoyant scuba diver and how long the dive would be able to stay under the water.
- Students would test the density of random materials as a support for their durability as casts for broken bones that have become deteriorated.
- Students will research the density of the 10 major bones of the skeletal system and then find alternate substances that may act as substitutes for these bones. They must have the same densities.
- In this lesson, teams of middle school students explore the engineering design process and the materials used in packaging by designing and testing a package that can protect a snack from heat and water.

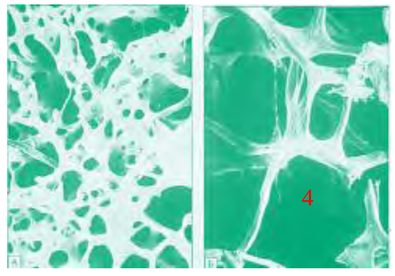
Chosen Solution

Client Statement

Using materials provided in class, create substitute bones out of the materials that will have the same density. This means the materials will have to have the same density as the original bones. Correct measurements of mass and volume are important since this will allow for the accurate calculation of density.

Objectives

1.Students will be able to use the engineering design process to find substitute bones. (ETS1)
2.Students will be able to calculate density.
3.Students will be able to explain the concept of density.
4.Students will be able to share with the class their findings.



Constraints

1. Students must work in groups
2. Project and presentation must be completed in 9-10 class periods
3. Use the materials supplied by the teacher in the classroom; laminate, woods, metals…
4. The work must be shown for each material that is attempted within the group
5. All members of the group must have a speaking part of the presentation upon completion of the project

Implementation

- What are bones made of?
- Density of your bones?
- Bones or Not?- Paired Reading
- Bones or Not?- Vocabulary
- So what is the density?
- Is there a substitute? (2-3 days)
- Share your findings! (2-3days)

Assessment

Formative Assessment

1. Informal questioning/conversation- used to assess knowledge of density
2. Check in with groups to monitor progress or redirection of tasks
3. Daily conclusion question to be written in journal and/or white board

Summative Assessment

1. Class presentation to communicate findings of task given
2. Evaluation lab sheet with data from hands-on activities

Future Work

Conclusions

Upon completion of this unit the students will:

- Effectively teach the Engineering Design Process
- Calculate and define density
- Communicate and present a project
- Differentiate between volume and mass
- Use hands-on problem solving skills
- Research skills

Future

- This unit is to be implemented during the upcoming school year, 2012-2013., at Fuller Middle School.
- Curriculum will be submitted to teachengineering.org
- Revisions made as needed

Acknowledgements

WPI-NSF RET Program in Bioengineering EEC #1132628
Special thanks to Dr. Terri Camesano and Dr. Kristen Billar for including me in this Biomedical Engineering training program
Dr. Chris Sotak for assistance with the design process
Special thanks to Dr. Jeanne Hubelbank for the excellent facilitation
Special thanks to my project partner Kerin Biggins for his input and patience.

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E.G. Benedict's Ambulance: Teaching Engineering through Transportation Technology and Patient Safety

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Introduction

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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: 9 class 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 9 (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. *Structural Engineering:* Design a deck that is not only handicapped accessible, but is designed to increase the quality of life for people with physical disabilities.
2. *Assistive Device Door Stop*: Use the engineering design process to develop a simple door stop that can be utilized by a person with limited mobility.
3. *Vehicle Safety Restraint System*: Design a passenger safety system for a patient in a model ambulance.

Chosen Solution

Client Statement:
Here at E.G. Benedict Ambulance Company, we pride ourselves in providing the most up to date, cutting edge, emergency response vehicles available. Through discussions with our customers, we have identified patient safety during transport as a major concern. This has now become a new focus for our development group. We would like you to design a patient safety system for our next generation ambulance. This safety system may be limited to the safety restraints, or include vehicle modifications. Patient safety is our number one goal.

http://missy3.tripod.com/CRASH.JPG

Objectives:
- Design and construct a patient safety system for an ambulance
- The safety system must keep the model patient (the raw egg) from breaking during the front end collision
- The safety system may be a combination of restraints and vehicle design

Testing:
- Patient safety will only be evaluated for front-end collisions
- Prototype will be rolled down a ramp and crash into the classroom wall
- Testing will begin with a ramp pitch of 1/8
- Ramp pitch will be increased with each successful crash

Deliverables:
- Three possible design solutions with pro/con list for each design
- Multi-view drawings of your selected safety system
- Classroom prototype
- Completed Engineering Design Process Packet
- Project debriefing presentation

Day	Task
1	Guided Background Research
2	Introduce the problem Define the problem General background research
Homework	Independently develop 3 possible solutions
3	Discuss possible solutions Create a pro and con list for each design Select best possible solution
4	Create formal designs Plan for material collection
5-7	Build patient safety system
8	Class Testing Completion of EDP packet
9	Class Debriefing

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.
•***Debriefing-*** The project debriefing presentations should include the test data, the interpretation of the data, and the future recommendations based on the data and their interpretations.

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 second trimester of the 2012/2013 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.offthemark.com/cartoons/2001-04-02.gif

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A Weighty Matter:

Designing a Way to Minimize the Loss of Bone Density Experienced by Individuals Living in Low Gravity Environments

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2012

Introduction

Changes in curriculum standards call for an integration of Science and Engineering in the classroom. Engineers, using the engineering design process, solve problems differently than scientists using the scientific method. In this unit, students will assume the role of engineers, as they work to solve an authentic bioengineering problem. In so doing they will:

- Examine the similarities and differences between the scientific method and the engineering design process
- Reinforce core curriculum concepts and math literacy while working through a design problem based on a current unit of study
- Investigate how bioengineering technologies are used to design and construct devices to improve health

Teaching Objectives and Constraints

Problem statement:
Design a curriculum unit, utilizing aspects of bioengineering and the engineering design process, that will reinforce concepts of gravity, weight, mass, volume and density while maintaining alignment with the Massachusetts Science and Technology/Engineering Frameworks.

Objectives:
- Improve student understanding of gravity, weight, mass, volume, and density
- Incorporate the use of the engineering design process in the classroom
- Provide students with real-world inquiry-based experiences

Constraints:
- Time allocated to teach the unit
- Meeting the needs of diverse learning populations
- Standards set by the DESE Frameworks and department curriculum

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

Student grade: 8th
Number of students: 20 to 24 per class working in groups of 3 to 4
Lesson duration: Nine 45 minute class periods

Research/Possible Solutions

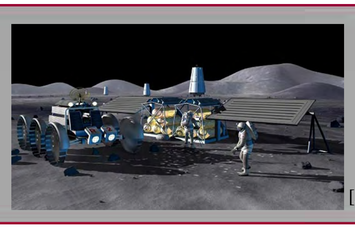
Possible Solutions:
While researching and developing this unit, the following possible solutions to the design problem were considered:
- Design an assistive device to help astronauts, encumbered by bulky spacesuits, reach specimens either on the surface of a planet or floating in space
- Design a device to help minimize bone loss for colonist living on either the Moon or Mars
- Design an apparatus to show that, due to the force of gravity, everything on our planet falls at the same rate
- Design a safety system to protect an individual in the event of a 20 foot fall
- Design an artificial, emergency lung to use in a low gravity situations

Research:
Mass DESE Frameworks
NSF Standards
www.teachengineering.org
RET Discussion Groups

Chosen Solution

Problem Statement:
As we consider the establishment of colonies on other celestial bodies, such as the Moon or Mars, thought must be given to the long term effects of living where the surface gravity is much lower than the Earth's will have on the body.
- Bone density loss for astronauts in space averages 1 to 1.5% per month
- The cumulative effects of living in a low gravity environment, such as the Moon or Mars, may end up being more severe, possibly keeping an individual from returning safely to the Earth

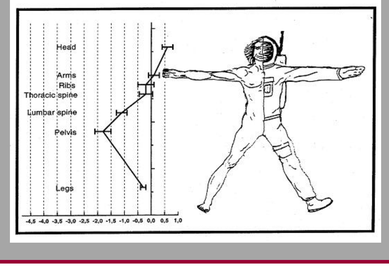

[1]


[2]

Client Statement:
Design a device to minimize the loss of bone density experienced by colonists living on a celestial body, such as the Moon or Mars, with a lower surface gravity than the Earth.

Objectives:
- Discover changes that reduced gravity can have on bone density
- Gain a perspective of what being in a low gravity environment would feel like
- Use the engineering design process to devise a means offsetting the loss of weight bearing forces experienced on celestial bodies with low surface gravities

Constraints:
- Designed and completed by groups of 3 or 4 students
- Completed and ready to present in 9 days
- Increase weight bearing forces on an individual so as to produce "Earth-like" forces on the body for a location with a lower surface gravity than the Earth
- Resistance can only be provided by means of resistance bands and/or weight add to backpacks
- Resistance bands limited to a minimum of 2 and a maximum of 6
- At least 85% of the resistant force must come from a combination of resistance bands of different strengths



[3]

Percent of bone density lost per month by astronauts while in outer space. Note that not all bones in the body experience the same amount bone loss.

Implementation will include:
- "Combating Bone Loss is Space" activity
- "Investigating Changes In Bone Density" laboratory investigation
- "Universal Weight?" activity
- Instruction on the steps of the Engineering Design Process
- Student research on loss of bone density in space
- "Resisting Weight Change" activity
- Designing, testing, and communicating students' solutions to the design problem

Assessment

Formative Assessment:
- Informal conversations with individuals and project groups to check on level of understanding with respect to the core concepts
- Frequent check-in to monitor progress of project, providing assistance and/or redirection when needed

Summative Assessment:
- Lab based activities to check for student understanding
- Evaluation of students' final design solutions to assess level of mastery with respect to the engineering design process
- Project write-up and class presentations to increase communication skills

Future Work

Conclusions
Upon completion of the unit students should be able to:
- Differentiate between weight and mass
- Define gravitational pull
- Calculate the weight of an object for locations with different surface gravities
- Differentiate between volume and mass
- Define and calculate density
- Use the steps of the engineering design process to effectively solve a bioengineering problem

Future
- Unit will be taught during the upcoming school year at Tantasqua Regional Jr. High School, results will follow
- Unit will be modified, as needed, to further meet the needs of the students and their obtainment of the learning objectives
- Curriculum will be submitted to www.teachengineering.org

Acknowledgements

Special thanks to:
- Terri Camesano Ph.D. and Ivan Ivanov: Project Mentors
- Kristen Billiar Ph.D. & Terri Camesano Ph.D: RET program PIs
- Anthony Gleason: Project partner
- Jeanne Hubelbank Ph.D.: Independent assessor
- National Science Foundation: Research Funded by NSF EEC #1132628

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Helping a Fellow Student:
Device design to aid a student's return to school

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Introduction

Engineering is evident in our daily lives through all of the ubiquitous technology in our world. Biomedical engineering is an exciting, relatively new area of engineering that focuses on applying the engineering design process to the fields of biology and medicine. This unit allows students to learn about both the engineering design process and biomedical engineering.

Problem: Problem: Teach the engineering design process through a biomedical engineering project. The engineering design process is not covered in the district science textbook, but it is assessed by state standardized testing.

Teaching Objectives and Constraints

Objectives: Students will be able to
* explain the steps in the engineering design process and why they are important
* use the EDP to construct a prototype
* provide examples of assistive devices and reasons people may need one

Constraints:
* students' lack of experience of the engineering design process
* MA frameworks
* limited time
* safe, age-appropriate materials and tools

Topics covered:
Engineering Design Process, Adaptations

Student grade: 4th grade
Numbers of students: 44 students between 2 classes
Number and duration of class periods: Approx. 2 weeks x 40 minutes

Research/Possible Solutions

Alternative project ideas include:
1. Design a device to protect an athlete during a dangerous sport
2. Design a shoe to be used for a given activity
3. Observe an animal's adaptations and design a device that uses biomimicry to help a human user
4. Design a device to help an injured pet

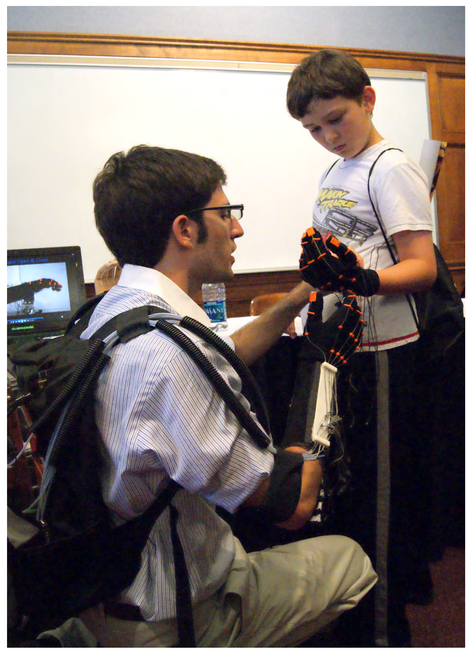
Chosen Solution

Problem/Client Statement:
Design an assistive device for a student with limited dexterity (no thumbs) to allow that student to participate in everyday school activities.
Constraints
* Only use supplied materials
* Must work in groups of 4
* Must be completed within 8 class periods

Implementation
Day 1: Pre-test and overview of the engineering design process and how it has affected our daily lives
Day 2: Introduction to client problem (thumb aplasia)
Students wear modified gloves and attempt various tasks.
Day 3: Teams brainstorm possible design tasks for approval. Groups having difficulty will be provided suggestions such as:

- Write
- Use a pencil sharpener
- Swing a wiffle ball bat
- Use scissors
- Eat school lunch / use spork

Day 4: Research using iPads for existing solutions. Homework of three design possibilities sketched.
Day 5: Students meet and decide on design solution.
Days 6 & 7: Construct and test prototype using materials in class.
Day 8: Groups demonstrate their design solutions. Homework: reflection worksheet/paragraph.



Assessment

Testing your solution against your objectives

Formative

- Engineering design pre-test
- Science/engineering notebook entries
- Classroom and small group discussion participation

Summative

- Engineering design post-test
- Final prototype
- Reflection worksheet

Future Work

Unit will be submitted to teachengineering.org to share with other technology teachers after it is taught.
Unit will be revised from year-to-year as needed to further meet the needs of students and the learning objectives

Acknowledgements

Special thanks to Kristen Billiar, Terri Camesano, and Jeanne Hubelbank for making the RET experience run as smoothly as possible.

This program was funded by the National Science Foundation EEC#1132628

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Got Water?
Clean Drinking Water for Campers

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Introduction

Life science at Chocksett Middle School is taught to approximately 110 seventh grade students who are divided into five classes. All of the Massachusetts State Frameworks for Life Science are covered during the year.

Students tend to favor hands-on projects and activities. The introductory unit Needs of Living Things (water, food and shelter) is one area that is currently lacking in this type of activity would be.

Problem Statement: Introduce students to the engineering design process in an engaging hands-on lesson while also covering strands from the Massachusetts life science curriculum frameworks.

Teaching Objectives and Constraints

Objectives:
- Use the steps of the Engineering Design Process
- Address the Needs of Living Things (water, food, shelter) unit
- Be hands-on and engaging

http://www.amazingaustralia.com.au/animals/koalas.htm

Constraints:
- Must relate to biomedical engineering
- Must be done in the regular classroom
- Must not take too much instructional time
- Must not take too much physical space
- Must engage students

Research/Possible Solutions

Possible solutions:
- Students design a water purifier for use on a camping trip to relieve the camper of carrying potable water
- Students design a soil additive to optimize growing conditions in arid, nutrient deficient soil areas
- Students design an adaptation for humans that makes food gathering easier in an imaginary environment
- Students design a decomposition chamber for more efficient degradation of waste to prevent overfill of landfills
- Students design a plant growth chamber for growing plants on the moon to supplement astronauts' meals

Chosen Solution

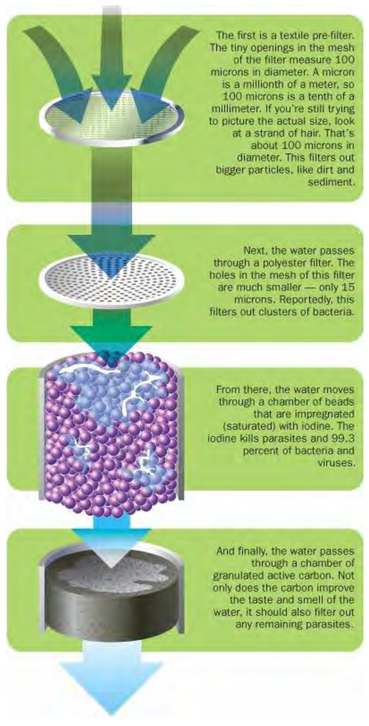
Best Solution: Using the Engineering Design Process, design a water purifier for use on a camping trip that will relieve the camper of carrying potable water

Objective: Construct a portable water filter and purifier that can remove contaminants from teacher-made polluted water. The processed water will be tested for the presence of
- bacteria
- nitrates
- phosphate
- dissolved oxygen
- acidic pH
- sediment

http://crossfitadventure.com/2011/01/21/drink-more-water/

Constraints:
- Filter must contain only four types of teacher-approved materials
- Filter must fit into a 2 liter soda bottle
- Construction must cost less than 500 Padilla pesos
- Filter must not contain any chemicals harmful to human consumption
- Filter must not weigh more than 1,000 grams

Implementation:
1. Discussion of the needs of living things (food, water and shelter) (1/4 class)
2. Class discussion of problem statement (1/4 class)
3. Class discussion of objectives and constraints (1/2 class)
4. Research different materials (1 class)
5. Test different materials (1 class)
6. Design filter (1/2 class)
7. Build filter (1/2 class)
8. Test filter (1 class)
9. Report results (2 classes)



http://bigberkeyfilters.net/berkey/wp-content/uploads/2011/08/gravity.jpg

Assessment

Formative assessment:
- Based on discussion and exit slips, students understanding of the EDP will be assessed

Summative assessment:
- Based on a rubric, students' posters presenting steps of the EDP will be scored
- Based on a rubric, student filtering success will be assessed

http://environment.nationalgeographic.com/environment/photos/scariest-freshwater-animals/#/environment-mata-mata-turtle_42561_600x450.jpg

- Based on packet, students will be assessed on understanding of EDP and ability to apply the process to a problem situation

Future Work

Conclusion: Students who complete this unit should have an understanding of
- what happens at each step of the EDP
- why clean water is needed
- how materials can be used to filter water

Future: With more familiarity of the process more EDP based projects will be used in the classroom

Acknowledgements

Special thanks to:
RET program PIs- Dr. Terri Camesano and Dr. Kristen Billiar-
Project facilitator- Dr. Jeanne Hubelbank
Fellow RET participants
The National Science Foundation Grant EEC 1132628

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Give Me a Hand- I Hurt My Foot!

Design of a Carrying Device to Assist a Person on Crutches

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Introduction

Purpose
- Engineers improve human life by solving problems.
- 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:
- Improves human health through cross-disciplinary activities
- Integrates the engineering sciences with the biomedical sciences and clinical practice [2]

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 to develop understanding of the Engineering Design Process that uses Biomedical Engineering.

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
- Limited design experience/working with open-ended problems
- Limited background knowledge
- Limited knowledge of Engineering
- Limited project resources (e.g., time, money, materials, work area)
- Various learning styles

Topics Covered Engineering Design, Biomedical Engineering

Grade Level	Grade 8
Number of Students	25-30
Lesson Duration	15 classes, 50 minutes

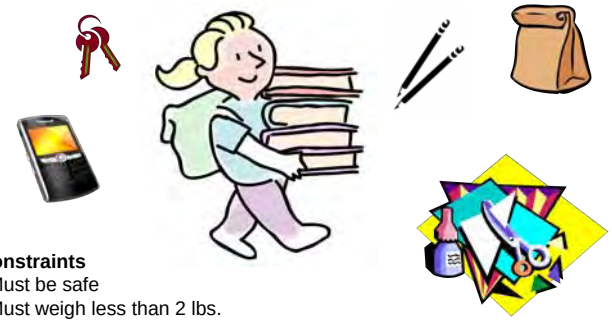
Research/Possible Solutions

- 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 to carry books and small objects for a person on crutches
- Design a floatation device to allow a handicapped person to go swimming

Chosen Solution

Problem Statement
Design a device to carry books and small objects for a person on crutches

Objectives
1. Students will solve an open-ended design problem
2. Students will apply the Engineering Design Process to solve a problem
3. Students will develop multiple solutions to the problem



Constraints
- Must be safe
- Must weigh less than 2 lbs.
- Must carry a minimum of 4 lbs.
- Must attach to a pair of crutches (or individual crutch)
- Must develop two possible designs
- Must be completed in three weeks
- Must be completed in the Technology/Engineering Lab
- 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

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

Summative Assessments
1. Completion of project- indicates application of the EDP
2. 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.[3]

Future
- Unit will be taught during the 2012-13 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
- 2012 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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