Research
Experience for
Teachers at WPI:
Bioengineering Design
in the Middle School
Classroom

Curriculum design process
&
Curriculum unit descriptions
2010

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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.

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Assistive Technology: Build a Reaching Device

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Introduction

Purpose of Curriculum Unit:
1. Show students an application of the engineering design process
2. Emphasize the importance of redesign so that students have an accurate understanding of trial and error
3. Give students exposure to biomedical engineering and assistive devices and relate this field to the character virtues

In this unit...
1. Students apply the steps of the engineering design process to create a reaching device
2. The device will help an elderly or disabled person who has difficulty gripping and holding objects

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 the purpose of assistive devices
2. Understand the steps of the engineering design process
3. Describe the relationship between forces and motion

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

Topics covered: technology, engineering, physical science
Student grade: 8th
Numbers of students: 24 per class
Number and duration of class periods: 10 periods, 45 min/class

Research/Background

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 an assistive device for an elderly person or a disabled person who may have difficulty gripping and reaching various objects – Best meets objectives and constraints

The chosen solution best supports the science content and curriculum that the students investigate in the 8th grade.

Chosen Solution

Problem Statement:
Design and build a device that lets you grab different objects and drop them into a container that is at least two feet away from you. The reaching device should be able to pick up a variety of objects, such as a tennis ball, a cotton ball, a plastic soda bottle, and paper cups.

Constraints: The device should:
1. Be able to pick up a variety of objects
2. Be able to drop the object into a container that is at least two feet away from you
3. Be constructed from materials provided by your teacher
4. Weigh less than 5 pounds
5. Have moving parts

Students will:
1. work in groups of two
2. relate engineering to character education
3. create sketches, orthographic projects, and multiview drawings of their solutions
4. learn to create design specifications and rating systems
5. gain exposure to material science by working with concepts such as stress and strain

The teacher will:
1. emphasize trade-offs and redesign so students understand application of the engineering design process
2. encourage students to relate the engineering design process to real-life design problems such as the computer, the automobile, the iPod, etc

The teacher will determine if the students’ projects demonstrate understanding and comprehension of:
1. assistive devices
2. the engineering design process
3. the relationship between forces and motion

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
   - list and explain 5 trade-offs they have made in their design

Conclusions and Future

1. Ask students to share examples of assistive technology that they have used in their lives
2. Students can consider the legal aspects of rehabilitation engineering by analyzing the various sections of the Americans with Disabilities Act
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 reaching device that can pick up two objects at once
2. Add a second motion to the reaching device, such as making the stick that holds the jaws able to bend like an elbow or extend another two feet and then retract

Acknowledgements

Allen Hoffman, PhD
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Jeanne Hubelbank, PhD

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Curriculum Unit and Assessment Plan

Assistive Technology: Build a Reaching Device

RET Project Connection

I worked in the Assistive Technology Resource Center lab. The purpose of the ATRC is to design prototypes of mechanical devices to assist individuals with disabilities. My partner and I worked on designing and creating a Frisbee thrower that is activated by a single switch. My research experience was directly related to my curriculum unit because they both involve designing assistive technology.

Subject Area technology, engineering, physical science

Key words/Vocabulary engineering design, prototype, biomedical engineering, forces, motion

Grade Level 6-8

Time Required 10 class periods, 45 minutes/class

Learning Objectives

At the end of the lesson, the students will be able to:
1. Explain the purpose of assistive devices
2. Understand the steps of the engineering design process
3. Describe the relationship between forces and motion

Prerequisite knowledge

Students should have a basic understanding of the term “biomedical” and should also be able to define and explain the term “engineering.” They should also have familiarity with the terms “forces” and “motion.”

Educational Standards

1. [Technology/Engineering, Grades 6-8, #1.1] Given a task, identify appropriate materials based on specific properties and characteristics
2. [Technology/Engineering, Grades 6-8, 2.1] Identify and explain the steps of the engineering design process
3. [Technology/Engineering, Grades 6-8, 2.2] Demonstrate methods of representing solutions to a design problem
4. [Technology/Engineering, Grades 6-8, 2.3] Describe and explain the purpose of a given prototype
5. [Technology/Engineering, Grades 6-8, 2.4] Identify appropriate materials, tools, and machines needed to
   construct a prototype of a given engineering design
6. [Physical Science, Grades 6-8, #11] Explain and give examples of how the motion of an object can be described
   by its position, direction of motion, and speed.

Introduction/motivation

Elderly persons or people with disabilities may have difficulty with everyday tasks. Assistive devices are products and
   tools that can help make life easier for certain people. These simple devices allow disabled persons to continue to cook,
   clean, get dressed, bathe, and move around with relative ease.

In this project you will be asked to design a device that can be used to grip a variety of items, such as a tennis ball,
   cotton ball, plastic soda bottle, and paper cups. The elderly or persons with certain types of arthritis or other disabilities
   may have difficulty reaching and picking up various objects. The work you complete in these activities will contribute
   toward improving the quality of life for people who need assistance.

Lesson background and concepts for teachers

Assistive Technology

Assistive technology is defined in the Technology-Related Assistance for Individuals with Disabilities Act of 1988 (P.L.
   100-407) as “any item, piece of equipment, or product system, whether acquired commercially, modified, or
   customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities.”

Examples of assistive technology devices include:
   • Hearing aids
   • Ramps that help people get in and around buildings more easily
   • Wheelchairs
   • Computer modifications to increase accessibility
   • Electronic devices that make communication possible
The Americans with Disabilities Act extends full civil rights and equal opportunities to people with disabilities in both the public and private sectors. Specifically, the law prohibits discrimination on the basis of a physical or mental disability in employment, public services, public accommodations, and telecommunications. Assistive technology allows engineering and design to fulfill many of the goals of the ADA.

**The Steps of the Engineering Design Process**

1. Identify the need or problem
2. Research the need or problem
   - Examine current state of the issue and current solutions
   - Explore other options via the internet, library, interviews, etc.
3. Develop possible solution(s)
   - Brainstorm possible solutions
   - Draw on mathematics and science
   - Articulate the possible solutions in two and three dimensions
   - Refine the possible solutions
4. Select the best possible solution(s)
   - Determine which solution(s) best meet(s) the original requirements
5. Construct a prototype
   - Model the selected solution(s) in two and three dimensions
6. Test and evaluate the solution(s)
   - does it work?
   - does it meet the original design constraints?
7. Communicate the solution(s)
   - Make an engineering presentation that includes a discussion of how the solution(s) best meet(s) the needs of the initial problem, opportunity, or need
   - Discuss societal impact and tradeoffs of the solution(s)
8. Redesign
   - Overhaul the solution(s) based on information gathered during the tests and presentation

**Forces and Motion**
Newton's first law of motion is often stated as “an object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.”

**Associated Activities**

**Materials:**
- Brass fasteners
- Corrugated cardboard
- Hole punch
- Rubber bands
- Sandpaper
- String
- Tape (duct or masking)
- Scissors
- Toothpicks
- Wooden skewers
- Yardsticks (or long paint stirrers for 5-gallon buckers)

**Day 1:**
1. Have a class discussion on the societal influence of engineering. Are engineers obligated to help fellow human beings?
3. **Group Activity:** Arrange students into small groups. Assign each an assistive device. Choose from the following:
   - Hearing aids
   - Ramps that help people get in and around buildings more easily
   - Wheelchairs
   - Computer modifications to increase accessibility
   - Electronic devices that make communication possible
   - Equipment on the job that has been modified or customized
   - Remote control devices that turn appliances, computers, lights, radios, etc. on and off
   - Magnifier, talking books, captioned television
Each group should produce a written response that explains why the selected device can serve as assistive technology. Share responses as a class.

Day 2:
1. Discuss the steps of the engineering design process.
2. Present a real life engineering design problem (the design of the computer, the automobile, the iPod, etc).
   Outline how the steps of the design process apply to the real life problem.
3. Define “trade-off” as it applies to engineering design. Give examples.
4. Ask students to reflect on the importance of learning from your errors and creating improvements. How does this apply to engineering design?

Day 3:
1. Define Problem Statement: Design and build a device that lets you grab different objects and drop them into a container that is at least two feet away from you.
2. Creating Specifications/Requirements for your device.
   a. Function
   b. Performance
   c. Safety
   d. Cost
3. Have students brainstorm:
   a. How will your device open and close so it can grip and object and let it go?
   b. How will you attach your grabber to the end of the stick?
   c. How will you control your grabber when it’s at the end of the stick?
4. Discuss how to create top-view and side-view drawings. Show examples.

Day 4:
1. Arrange students in groups of two.
2. Students should work on creating 3 possible designs solutions.
   a. Include a top-view and side-view drawing of each
   b. List the pros and cons of each design
   c. Give each design a rating (1-10) in terms of your specification categories.
3. Students begin constructing their reaching device.
Day 5:
Students continue constructing their devices.

Day 6:
1. Students continue constructing their devices.
2. As they finish, ask them to:
   a. create a 2 page written response that details how they have demonstrated each step of the engineering design process
   b. list and explain 5 trade-offs they have made in their design

Day 7:
1. Testing phase: Students can test the reaching device by trying to pick up different objects. As they test, the design may not work as planned.
   a. Emphasize that when engineering solve a problem, their first solution is rarely their best. Instead, they try different ideas, learn from mistakes, and try again.
   b. Students should study the problems and then redesign.
2. Students continue working on their written response on the EDP and trade-offs.

Day 8:
1. Redesign: If the reaching device has a problem with grip, holding, bending, twisting, or control, encourage students to make the appropriate adjustments.
2. Students continue working on their written response on the EDP and trade-offs.

Day 9:
1. Continue redesign.
2. Students continue working on their written response on the EDP and trade-offs.

Day 10:
1. Present projects to the class.
2. Rubric is used to assess project presentations.
Lesson closure

1. Ask students to share with the class examples of assistive technology that they have used in their lives. Explain and discuss how assistive devices can help even small disabilities, such as vision problems.
2. **Optional Conclusion Activity:** Some people have trouble with fine motor coordination. This is because their muscles are weaker, and they need more time and practice to learn how to move. Have the students put a pair of thick socks on each hand and try to tie shoes, button a shirt and string beads.
3. Provide students with research and information on the Americans with Disabilities Act of 1990. Have them work in small groups to analyze each of the various titles (Employment, Public Entities, Public Accommodations, Telecommunications). They should also brainstorm examples of equal rights and discrimination. Students should create presentations and share as a class.

Lesson extension activities

1. Build a reaching device that can pick up two objects at once.
2. Add a second motion to the reaching device, such as making the stick that holds the jaws able to bend like an elbow or extend another two feet and then retract.

Assessment

1. Formative assessment during class activities
2. Project presentations
3. Written response that includes:
   - Details on how they have demonstrated each step of the engineering design process
   - List and explain 5 trade-offs they have made in their design

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Summary

Assistive technology uses engineering to create devices that allow disabled persons to increase, maintain, or improve functional capabilities in their lives. In this curriculum unit, students will design and build a device that allows the user...
to grab different objects and drop them into a container at a two foot distance. By following the steps of the engineering design process, students will brainstorm, analyze and critique possible solutions, and then building, test, and evaluate a prototype design. There will be an emphasis on trade-offs and redesign so that students understand the application of the EDP.

**Engineering Connection**

Engineering design process

**Engineering Category**

rehabilitation engineering

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Design a Device to Simulate Human Interaction

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Introduction

Research suggests students retain 10% of what they read, 20% of what they hear and 40% of what they say and do.1 Using the Engineering Design Process (EDP) to solve a biomedical engineering (BME) problem students will be engaged in a hands on activity that incorporates research, design and testing. This curriculum incorporates parts of the Massachusetts Science and Technology/Engineering Frameworks. Through this experience students should also achieve a deeper level of understanding in regard to research and applied knowledge. The curriculum will allow students to follow the design process and create a device that will aide in the improvement of a living organism.

Teaching Objectives and Constraints

Problem Statement: Design a curriculum for seventh graders that applies the EDP to solve a biomedical engineering problem. The unit will allow students to create a device that will aide in the improvement of a living organism. This unit will align with some aspects of the Massachusetts Science and Technology/Engineering Frameworks.

Objectives:
1. Students will research skills to understand and explain the structures and functions of various human body systems such as the nervous system, cardiovascular system, integumentary system and the senses.
2. Students will communicate their findings periodically throughout the EDP.
3. Students will design and create a waste containment unit or a water purification system to be used in remote wilderness areas or third world countries.
4. Students have very little experience with the EDP.
5. Course will be the last period of the day (seventh period), equity of seventh period.
6. Students do not get a grade in an elective, only a Pass/Fail.
7. Research and oral presentation of findings
8. Research/Background

Research and oral presentation of findings

• Develop a prototype.
• Lessons and activities to learn the steps of the EDP, focus on research skills
• Research and applied knowledge. The curriculum will allow students to follow the design process and create a device that will aide in the improvement of a living organism.

Chosen Solution

• Best Solution: Using the EDP to learn about Biomedical Engineering create a device that would mimic human contact with newborn babies deprived of this stimulation (for example premature babies).
• Reason for the Selection: Incorporates the study of the EDP, educates students about biomedical engineering and allows students to solve a real life problem using science content.

Objectives:
1. Students will design and create a device using the EDP that would mimic human contact with newborn babies deprived of this stimulation in the neonatal setting.
2. Students will be working in pairs, develop possible solutions
3. Test and evaluate the solution, list pros and cons.
4. Finish poster and communicate the results (oral presentation), include any idea’s for redesign in the final oral presentation
5. Construction and human stimulation in newborns
6. Development, the integumentary system, the cardiovascular system and the senses as well as stimulus/response in organisms.

Constraints:
1. The device must:
   a. conform to a specified size
   b. simulate human touch by having one part of it move
   c. use material that feels like human skin
   d. have the ability to play music, a human voice or a heart beat
   e. have the ability to heat the device for 20 minutes at 37 degrees Celsius
2. This course is graded as a Pass/Fail however students will be provided with a grade for their own sense of accomplishment.
3. Pre-survey: Use to gather information regarding students prior knowledge, attitudes, confidence and misconceptions about engineering and the design process.
4. Post survey: Will compare their new knowledge with information from the pre-survey.
5. Formative assessments will be used along the way to check for understanding.
6. Periodic checks of student journal (formative assessment).
7. A rubric will be used to determine grades for the final project.
8. A rubric will be used to determine grades for the final project presentation and oral presentation (summative assessment).
9. Tests and examinations are not a part of this project.

Assessment

Conclusions and Future

Conclusion:
At the end of this 20 week course students should:
1. Be able to apply the EDP to problem solve.
2. Be able to communicate their progress using EDP as a guide.
3. Be able to communicate their results in the form of an oral poster presentation.
4. Realize that the EDP is something that is attainable for all students to use and understand.
5. Have a greater understanding of the nervous system, specifically brain development, the integumentary system, the cardiovascular system and the senses as well as stimulus/response in organisms.

Future:
1. Using a before and after survey about the EDP I will evaluate this course and make changes accordingly.
2. It is my hope that students who participate in this course will want to use the EDP to complete a science fair project and participate in the WRSEF.
3. It is also my hope that students who complete this course will realize that engineering is a career that can be attainable.

Acknowledgements

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Curriculum Unit and Assessment Plan

Using the EDP to Solve a Biomedical Problem

RET Project Connection:

The task when working in Dr. Glenn Gaudette’s lab focused on designing a device to efficiently and repeatedly group four to twelve fibrin microthreads into a single bundle. This bundle will then be used as a suture to introduce stem cells to the myocardium. The bundling process should create equal tension amongst the threads and maintain equal spacing throughout. Additionally the bundling process must recognize the delicate nature of the threads and be able to preserve the structure of them. Overall the device should minimize user interface while creating bundles of threads with consistent mechanical strength. The experience as a RET Teacher allowed me (and a colleague) to work through the Engineering Design Process (EDP) within the Biomedical Engineering Department. This experience has enhanced not only my understanding of the EDP but also my content knowledge. Our task was to develop a device to improve the process of bundling fibrin and collagen threads. Although the specific project does not coincide with my curriculum project the process does. I feel the process is extremely valuable for a middle school student so instead of developing a unit to incorporate EDP into an already full life science curriculum I am developing a Engineering Design science elective course with a focus on Biomedical Engineering.

Subject Area
Life Science, specifically body systems, Physical Science, specifically heat transfer, the engineering design process (EDP)

Key words/Vocabulary
engineering design process, biomedical engineering, nervous system, brain development, integumentary system, cardiovascular system, senses, stimulus/response, newborns, kangarooing
Grade Level  What grades could this be applied to? Grades 7 and 8
Time Required  What was the originally planned number of lessons and time per lesson:
20 weeks, 42 classes, 50 minutes per class

Learning Objectives

At the end of this 20 week course students should...

• Be able to apply the EDP to problem solve.
• Be able to communicate their progress using EDP as a guide.
• Be able to communicate their results in the form of an oral poster presentation.
• Be able to communicate their results in a science lab journal.
• Realize that the EDP is something that is attainable for all students to use and understand.
• Have a greater understanding of the nervous system, specifically brain development, the integumentary system, the senses, and the cardiovascular system as well as stimulus/response in organisms.

Prerequisite knowledge

Since this will be a 20 week course students do not need prior knowledge of the engineering design process.
Educational Standards: Massachusetts Science and Technology/Engineering

Life Science 6-8 Standards

Classification of organisms

- 1. Classify organisms into the currently recognized kingdoms according to characteristics that they share. Be familiar with organisms from each kingdom.

Structure and Function of Cells

- 4. Recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out. The way in which cells function is similar in all living organisms.

Systems in Living Things

- 5. Describe the hierarchical organization of multicellular organisms from cells to tissues to organs to systems to organisms.

- 6. Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination) and describe ways that these systems interact with each other.

Physical Science 6-8 Standards

Heat Energy

- 1. Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system.

- 2. Explain the effect of heat on particle motion through a description of what happens to particles during a change in phase.

- 3. Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium.

Technology/Engineering Standards

Science/Technology 6-8

1. Materials, Tools, and Machines

- Central Concept: Appropriate materials, tools, and machines enable us to solve problems, invent, and construct.

- 1.1 Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g., strength, hardness, and flexibility).

- 1.2 Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use.
2. Engineering Design

- **Central Concept**: Engineering design is an iterative process that involves modeling and optimizing to develop technological solutions to problems within given constraints.

- 2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

- 2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.

- 2.3 Describe and explain the purpose of a given prototype.

- 2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.

- 2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.

- 2.6 Identify the five elements of a universal systems model: goal, inputs, processes, outputs, and feedback.

3. Communication Technologies

- **Central Concept**: Ideas can be communicated through engineering drawings, written reports, and pictures.

- 3.2 Identify and explain the appropriate tools, machines, and electronic devices (e.g., drawing tools, computer-aided design, and cameras) used to produce and/or reproduce design solutions (e.g., engineering drawings, prototypes, and reports).

4. Manufacturing Technologies

- **Central Concept**: Manufacturing is the process of converting raw materials (primary process) into physical goods (secondary process), involving multiple industrial processes (e.g., assembly, multiple stages of production, quality control).

- 4.1 Describe and explain the manufacturing systems of custom and mass production.

- 4.3 Describe a manufacturing organization, e.g., corporate structure, research and development, production, marketing, quality control, distribution.

- 4.4 Explain basic processes in manufacturing systems, e.g., cutting, shaping, assembling, joining, finishing, quality control, and safety.

7. Bioengineering Technologies

- **Central Concept**: Bioengineering technologies explore the production of mechanical devices, products, biological substances, and organisms to improve health and/or contribute improvements to our daily lives.

- 7.1 Explain examples of adaptive or assistive devices, e.g., prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces.
Introduction/motivation

After students have taken a pre-survey about their prior knowledge, attitudes, confidence and misconceptions about engineering and the design process the real introduction to the course will begin. Students will be given various items that have been engineered and have a story behind them (example Velcro). I will ask students if they have ever wished something they liked to do or something they used could be made better. Have them share their stories. As a class we will define engineering. As the first week of the course progresses we will discover the various kinds of engineers. Students will choose a problem in their everyday life they would like to solve. The teacher’s problem for example is to “figure a way to stop losing socks in the dryer so I don’t always end with an odd number”. Students will go through the design process with their problem. Using a DVD (“Innovations: Life Inspired”) and engineers (send out letter to parents to recruit speakers who work in this field) students can start to see that the engineering design process is something they can do. Once students develop an understanding of the design process the students will be given a real life problem “Create a device that would mimic human contact with newborn babies deprived of this stimulation (for example premature babies)”. Students will be motivated by a real life problem while using the EDP to learn about BME.

Lesson background and concepts for teachers

Teachers need to have prior knowledge of the EDP and an understanding of the different disciplines within engineering. The particular area of interest for this project is biomedical engineering. Teachers will also need to prepare materials and sites for students to research specific body systems (the Nervous System, brain development in newborns, Cardiovascular System, the senses and the Integumentary System). There is also research that exists about kangarooing and human contact and interaction with newborns. This research will need to be organized for students with some information being deleted so as to make it more appropriate for middle school students.
Associated Activities  (Tentative Overview)
After some introductory activities the curriculum will basically follow the EDP with special focus on research and communication skills.

- Week 1: Pre-survey, introduction activity, explain how to use a lab journal
- Week 2: Lessons and activities to learn the steps of the EDP, focus on research skills
- Week 3: Continuation of week 2, students make up their own problem to solve using EDP
- Week 4: Meet with students individually to hear their process for solving their problem
- Week 5: DVD: Innovation (biotechnology stories), careers, using the EDP in everyday life
- Week 6: Give students problem, write general client statement as a class
- Week 7: Divide students into research groups based on body systems (will simulate different labs), research
- Week 8: Continue research and prepare for oral presentation
- Week 9: Give guidelines for oral presentation, presentations
- Week 10: Finish presentations, as a class research the need
- Week 11: Students will be placed in pairs, develop possible solutions
- Week 12: Present possible solutions to the class in the form of a “lab meeting”
- Week 13: Using input from other groups each group will select the best possible solution
- Week 14: Student groups will construct a prototype. Work on poster.
- Week 15: Continue constructing the prototype. Work on poster.
- Week 16: Test and evaluate the solution, list pros and cons. Work on poster.
- Week 17: Finish poster and communicate the results. Include any ideas for redesign in the final oral presentation.
- Week 18: Finish oral presentations (if needed).
- Weeks 19 and 20: Work on a project to educate other students about the EDP and BME, for example making trading cards of various careers in engineering or a card that represents a famous inventor or scientist that used the EDP to solve a problem.
- * Invite parents to view projects. Also try to include various speakers throughout the course.

Physical Materials:
Small baby dolls, shoe boxes or plastic bins, cloth that feels like skin, filler material (bean bag filler), optional: hot water bottles, heating pad, rollers to simulate movement, mini tape recorder or something to simulate sound
Lesson closure

Students will have various opportunities to communicate their findings and get input from the class. Their final results will be presented orally using a poster to do the presentation. Following their presentations to the class, parents, teachers and other classmates will be able to view their “device”. Students will also complete a post survey. The results will be compared to the pre survey and the course will be adjusted accordingly.

Lesson extension activities

If time allows students will research careers in engineering and using teachengineering.org read about engineers and their career path. Given a choice of assignments students will then design a science trading card.

Additional multimedia support

Not required but computers are helpful for research, DVD player for the Inspirations DVD

Assessment: This course is graded as a Pass/Fail however I will be providing students with a grade for their own sense own accomplishment.

Pre-survey:

- Used to gather information regarding students prior knowledge, attitudes, confidence and misconceptions about engineering and the design process.
- Post survey: Will compare their new knowledge with information from the pre-survey.
- Formative assessments will be used along the way to check for understanding.
- Periodic checks of student journal (formative assessment).
- A rubric will be developed to grade the final journal (summative assessment).
- A rubric will be developed to grade the final poster presentation and oral presentation (summative assessment).
- Post survey: Gather information regarding students prior knowledge, attitudes, confidence and misconceptions about engineering and the design process.

Design a Device to Simulate Human Interaction: Using the EDP to Solve a Biomedical Problem 8/4/2010
References
http://engineergirl.org/
http://www.howstuffworks.com/ (general information for kids to research aspects of their design)
http://kidshealth.org (for kids, body system, good skin pics)
http://inventors.about.com (general information for kids to research aspects of their design)
Teacher Background:
http://telemedicine.org/anatomy.htm
(anatomy of the skin)

www.biomedcentral.com
(kangaroo care)
“Cerebral oxygenation responses during kangaroo care in low birth weight infants”
Electronic version: http://www.biomedcentral.com/1471-2431/8/51

http://www.pnas.org/
Early experience in humans is associated with changes in neuropeptides critical for regulating social behavior
Electronic version: http://www.pnas.org/content/102/47/17237.short

http://teachengineering.org/

http://www.naturalchild.org/james_kimmel/human_baby.html
(“The Human Baby”, by James Kimmel, Ph.D.)

http://www.mindpub.com/art173.htm
(“Human Touch is Necessary”, by Vijai P. Sharma, Ph.D.)

(“The Effect of Human Contact on Newborn Babies”)

Design a Device to Simulate Human Interaction: Design a Device to Simulate Human Interaction: Using the EDP to Solve a Biomedical Problem8/4/2010
Associated Unit

N/A

Lesson # of ___

N/A

Lesson Dependency

N/A

Summary

Students are taught the EDP to solve problems. The curriculum is set up to go through the process over 42 class periods. Students will learn about different areas of engineering by having speakers come in, watching videos, student research and discussion. A focus on Biomedical Engineering will guide the students through a project while incorporating some of the Massachusetts Science and Technology/Engineering Frameworks.

Engineering Connection

Engineering design process using a biomedical engineering problem

Engineering Category

Biomedical Engineering

Attachments

Coming Soon

Other, Related URL

N/A

Owner, Contributors, Copyright

RET Teacher  Lisa Greenwald
School  Sarah W. Gibbons Middle School
Town/District  Westborough, MA
Design of a Ligament Replacement for a Youth Knee Injury

Thomas Oliva
Forest Grove Middle School, Worcester, MA
WPI-NSF RET Program in Bioengineering, Worcester Polytechnic Institute, Worcester, MA
2010

Introduction

Purpose
• Design activities are one of the most prominent learning challenges
• Students will understand math and sciences through the challenge of doing and applying, not by passively observing and listening from a seat in a classroom

General Description
• Students engage in design challenges and safely work with materials to model and test solutions to a problem
• Tissue engineering develops biological substitutes to restore, maintain or improve tissue/organ function
• Students will "engineer" a substitute for a damaged tissue in the knee

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 increase student understanding of the Engineering Design Process
2. To increase student knowledge of Biomedical Engineering
3. To increase student problem solving skills

Constraints
• Limited design experience/working with open-ended problems
• Limited background knowledge
• Limited knowledge of Engineering

Objectives
1. Students will identify four examples of tissues in the human body
2. Students will apply the Design Process to solve a problem
3. Students will communicate the results of a design solution

Constraints
• Must be at least 4 inches long
• Must be no larger than ¼" in diameter
• Must be no larger than ¼" in diameter
• Must be at least 4 inches long
• Must be at least 4 inches long
• Must be at least 4 inches long
• Must be at least 4 inches long

Topics Covered
Engineering Design, Materials
Biomedical Engineering, Life Science

Grade Level
Grade 8

Number of Students
25-30

Lesson Duration
20 classes, 50 minutes

Research/Background

A large part of design is focused on materials. Everything around us has a design and is made of raw materials - including our bodies. Aluminum can be formed in large amounts to make engine blocks for cars or in very thin, light sheets to wrap up our food. Likewise, we have materials in our bodies, such as collagen, that can make up skin, tendons and ligaments, too. How materials are structured can determine how, where and why they are used.

Possible Solutions
• Design a piece of protective sports equipment
• Design a tissue substitute to replace a damaged ligament
• Design a piece of exercise equipment to be used in space (zero gravity)
• Design a patch as a scaffold to help damaged cartilage
• Design a device to test the tensile strength of soft biomaterials

Problem Statement
Design a tissue substitute to replace a damaged ligament

Chosen Solution

Objectives
1. Students will identify four examples of tissues in the human body
2. Students will apply the Design Process to solve a problem
3. Students will communicate the results of a design solution

Constraints
• Must be at least 4 inches long
• Must be no larger than ¼" in diameter
• Must hold a minimum of 135 pounds
• Must maintain a stiffness of 10-40 lbs./inch
• Must be completed in four weeks

Plan for prototyping and testing the solution
• Students will get instruction on the Engineering Design Process
• Students will conduct appropriate research
• Students will learn about objectives, constraints and functions and how to use them as criteria to design a solution to a problem
• Students develop solutions and build a prototype of their design
• Designs will be tested in class and presentations made to communicate the design solution

Assessment

Formative Assessment
1. Informal questioning/conversation - used to assess knowledge of biological tissues found in human body

Summative Assessments
2. Project Reflection Sheet - identifies knowledge of the Design Process
3. Final Presentation - indicates communication of design solution

Conclusions and Future

Conclusions
• This unit effectively teaches the Engineering Design Process
• Students will have a hands-on problem solving experience in Biomedical Engineering that addresses curriculum frameworks
• Teachers, curriculum, instruction methods and other academic experiences can have a huge influence on decisions, especially for women and minorities.
• Not cultivating qualities of engineering problem solving and design, and not modeling inquiry processes in young learners does us all a great disservice as we prepare for the future.

Future
• Unit to be implemented during 2010-11 school year
• Curriculum to be posted on www.teachengineering.org
• Revisions to be made to optimize objectives
• Unit could include design of planar tissue or cartilage replacement

Acknowledgements

• Dr. Terri Camesano and Dr. Kristen Billiar - development and implementation of the RET program in Biomedical Engineering
• Marsha Rolle - additional instruction on design and research
• Jeanne Hubblebank - keeping focus on curriculum and assessment
• Mark Williams - supporting the implementation of curriculum unit

References

Design a Ligament Replacement for a Youth Knee Injury

RET Project Connection

Biomedical Engineering is a rapidly growing field of engineering. It includes the subjects of biology, engineering and medicine. Engineering depends on the use of the design process so problems can be solved- including those associated with the human body. In Marsha Rolle’s BME lab at WPI, engineering students are working on various research projects that involve working with cells to grow and test new blood vessels- one kind of tissue in our bodies. To learn about engineering design, middle school teachers take part in a Research Experience for Teachers (RET) and work on research projects in the labs with the WPI students.

Biomedical engineers, engineering students, middle school teachers and middle school students all have something in common- a focus on the design process to be effective at what they do.

Subject Area

Engineering Design

Key words/Vocabulary

engineering design process, biomedical engineering, tissue engineering, ligament, knee anatomy, collagen, biomaterials, tension, braid, weave

Grade Level

Grade 8
Time Required 3 weeks, 15 classes, 50 minutes/class

Learning Objectives At the end of this lesson, students will be able to:
1. Identify three examples of tissues in the human body
2. Apply the Design Process to solve a problem
3. Communicate the results of a design solution

Prerequisite knowledge
A basic understanding of muscles, ligaments and tendons as well as joints in the human body.

Educational Standards

Massachusetts Curriculum Frameworks

Technology/Engineering

1. Materials, Tools, and Machines
1.1 Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g., strength, hardness, and flexibility).
1.3 Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) needed to construct a prototype of an engineering design.

2. Engineering Design
2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.
2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multi-view drawings.
2.3 Describe and explain the purpose of a given prototype.
2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.

Science
Systems and Living Things
6. Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination) and describe ways that these systems interact with each other.

Introduction/motivation
The human body is a fascinating machine. Like all machines, there are many moving parts. The various parts of our body depend on each other to give us support (skeleton) and motion (muscles, tendon and ligaments). Often we don't appreciate or understand the importance of these parts until they don't work properly due to injury, birth defect or other problem.

Biomedical engineers study the forces that affect various tissues in the human body. They use their scientific knowledge of forces to design various "fixes" for things that may not be functioning properly. Some things that may be improved or helped through biomedical engineering can include blood vessels, skin, bones and ligaments.

Tissue engineering is a discipline of Biomedical Engineering that is concerned with the integration of the principles and methods of engineering with the fundamentals of life sciences towards the development of biological substitutes to restore, maintain or improve tissue/organ function.

Lesson background and concepts for teachers

Biomedical Engineering
Biomedical Engineering addresses the development of devices and processes that aid humans with regard to biology, medicine and technology. Assistive and adaptive devices are important components of helping humans live better lives. Buildings are adapted to meet the needs of people with disabilities.

Engineering Design
Engineers develop solutions to problems we face in our lives. In order to successfully arrive at a solution to a problem, they follow a formal set of steps known as the Engineering Design Process. This process helps keep focus on the problem and its specific criteria. These criteria are known as objectives (desired outcomes) and constraints. These criteria are important as they serve as a guide to efficiently develop possible solutions for a client's needs. The design process is iterative and is not typically successful on the first attempt.
**Associated Activities**

**Week 1**
1. **Introduction to Engineering and the Design Process**
   - PowerPoint presentation with Engineering Design Process graphic and related information
   - Short activities that give student problem solving experience before starting this project

2. **Research**
   - Students will conduct research to learn background information about the design problem:
     - Biomedical Engineering, tissue engineering, ligament, knee anatomy, collagen, biomaterials, tension, braid, weave

**Week 2**
1. **Introduce specific project criteria**
   
   **Constraints**
   - Must be at least 4 inches long
   - Must be no larger than ¼” in diameter
   - Must hold a minimum of 135 pounds
   - Must maintain a stiffness of 10-40 lbs./inch
   - Must be completed in three weeks

2. **Begin developing design for ligament replacement**

3. **Build prototype of design**

   **Materials needed**
   - Suede lacing

4. **Conduct test on designed "ligament"**
Week 3
Communicate the results
• Students will create a presentation that shows steps of the design process as it relates to this project (not including Communicate Results and Redesign)

Lesson closure
Serious knee injuries such as a torn ACL can be rather common in sporting activities. Research knee injuries in a sport of your choice (e.g., soccer, field hockey, football). You may or may not find a torn ACL. Can you identify a specific knee injury and the treatment for that injury- they might vary (note: not all injuries require surgery and reconstruction)
• Identify how a specific injury was repaired
• Identify what materials (if any) were used
• Identify if any materials used were natural or synthetic

Lesson extension activities
N/A

Additional multimedia support
Video Clip- A Day in the Life of a Biomedical Engineer

Interactive Knee Anatomy resources
http://www.hipsknees.info/flash/HTML-KNEES/demo.html
http://www.hipsknees.info/flash/avisisknee.swf
http://www.coastsurgery.com/flash/kneeanatomy_ani.swf

Assessment
Formative Assessment
Informal questioning/conversation- used to assess knowledge of biological tissues found in human body

Summative Assessment
Project Reflection Sheet- identifies knowledge of the Design Process
Final Presentation- indicates communication of design solution

Attitude Assessment
Pre-test with questions regarding attitudes towards engineering
References

http://www.wpi.edu/academics/Depts/BME/About/te.html


Massachusetts Department of Elementary and Secondary Education

http://www.doe.mass.edu/frameworks/scitech/1006.pdf

Web pages and primary sources (all with active web links if possible).

Associated Unit

N/A

Summary

Students are first introduced to Biomedical Engineering. The basic biology of the system of muscles, ligaments and tendons within the human body is covered so students have an understanding of the function of these parts. Understanding the role and function of these parts is important background knowledge so students can begin to design a replacement part that needs to act just like the original one. Improving or maintaining the functionality of the human body is what Biomedical Engineering is all about.

Engineering Connection

Biomedical engineers work with medical professionals to develop solutions that directly aid problems with the human body. Whether a problem occurs in the heart, blood vessels, skin, bones or tendons and ligaments, issues can often be solved through the development of a new solution (engineering). Doctors may perform surgery and implant something completely new or repair part of something not working properly.

Engineering Category

Biomedical Engineering
Designing a Planaria Regeneration Chamber

Anastasia Padilla
WPI-NSF RET Program in Bioengineering, Chocksett Middle School, Sterling, MA

Introduction
Develop a life science related curriculum unit that allows students to use the Engineering Design Process and exposes students to current medical research.

Teaching Objectives and Constraints

Problem: Design a curriculum where students use the EDP to create a device for use in biomedical engineering

Objectives:
• To expose students to current biomedical research
• To give students an inquiry based research experience
• To increase student interest in science and scientific research
• To use the Engineering Design Process (EDP) to design the ideal regeneration chamber
• To connect growth and development to events found outside the classroom

Constraints:
• Must use the EDP
• Must be completed in six weeks
• Must cost less than $2 per group ($60 total) for materials
• Materials must be easily obtainable (local stores and water sources)
• Must apply to life science curriculum

Topics covered:
• Regeneration
• Controlled Experiments
• Designing an Environment

Unit Specifications:
• Seventh grade students
• Approx. 24 students per class
• Nine full class periods
• Twenty 15 minute observation times

Planaria are small, freshwater flatworms from the phylum Platyhelminthes. Planaria can be found in lakes and streams, usually in the leaf litter that covers the floor of these locations (2,4). What makes planaria unique is their ability to regenerate new body parts following segmentation. (1,3)

Planaria regeneration is currently being studied in relation to cancer cell growth and stem cell work, as well as molecular genetics. (1, 5)

Research/Background

Constraints:
• The environment must include the following
  • water nutrients
  • a controlled amount of light
  • a substrate
  • vegetation
  • temperature
• The environment must fit within a five inch diameter Petri dish
• The design of the environment must be based on initial research activity
• Two full class periods will be allotted for construction of final environment

Project Outline:
Research:
1. Students brainstorm ways to help the planaria regenerate faster.
2. Initial Research Activity (part 1): Students test out one idea from the brainstorm, monitoring for response to light, response to food and presence of eyespots.
3. Initial Research Activity (part 2): Students observe non-cut planaria for preferences of substrate, temperature and vegetation
4. Student present the findings of their tests

Design:
1. Students use the information they have learned to design a planarian regeneration assistive device
2. Students test out their design and report findings

References
RET Project Connection

Dr. Camesano’s lab and Dr. Liang’s lab are working together to come up with a material that could be used to coat catheters to prevent bacterial adhesion following implantation. When a catheter is inserted for medical reasons, the skin, a major organ of the body's immune system, is disturbed, allowing bacteria to enter. Once inside the body, bacteria form a biofilm. Once this happens, bacteria become impossible to destroy, resulting in the need to remove the catheter.

In particular, the material being studied is titanium dioxide arranged in a thin layer. Titanium dioxide has a crystal structure that when small enough, can puncture a hole in the bacterial membrane. Larger pieces of titanium dioxide can also be ingested by the bacteria, also causing cell death.

While this lesson does not directly address the coatings of catheters, it does look at additional research being done to help heal humans and regrow structures that might normally be replaced by an artificial substance.

Subject Area    Middle School Life Science
Key words/Vocabulary
regeneration, planaria, engineering design process
Grade Level    6 through 8
Time Required  9 full class periods to research, design and carry out activities
20 classes of 15 minute observation times.
Learning Objectives
• Recognize that some animals can regenerate major body part
• Recognize that humans can regenerate a very few body parts (skin, liver)
WPI-NSF RET in Bioengineering Design in the Middle School Classroom

- Describe some model organisms and why these model organisms are used
- Perform a controlled experiment

Prerequisite knowledge

- Students should have an understanding of what a controlled experiment is
- Students should have familiarity with how to use a microscope

Educational Standards

Content Standard A:
- Recognize that all organisms are composed of cells, and that many organisms are single-celled (unicellular), e.g., bacteria, yeast. In these single-celled organisms, one cell must carry out all of the basic functions of life.

Content Standard B:
- Recognize that within cells, many of the basic functions of organisms (e.g., extracting energy from food and getting rid of waste) are carried out. The way in which cells function is similar in all living organisms.

Content Standard C:
- Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

Introduction/motivation

When studying body systems and cell division, students always ask “why can a starfish regrow an arm but I can’t?” The answer to this question to some extent still remains a mystery, but students will be motivated by the chance to experiment and see regeneration in action.

In addition, science is often studied in a classroom setting, with little connection to the outside world. This unit attempts to address the several ideas. First, it will introduce students to a simplified version of real world experiments. Second, it will allow for a discussion of why scientists use model organisms. Third it is an inquiry type lab that does not have any correct outcome or results, so students will experience first hand what real science is like.

Lesson background and concepts for teachers

Planaria, from the phylum Platyhelminthes, are small flatworms that live in freshwater ponds and streams. Usually they are between 3 mm and 15 mm in length, although some land species can grow to much bigger sizes. Planaria consist of a head region, a midsection and a slightly pointed tail. On the triangle shaped head are two photoreceptor “eyes” which
the planaria use for sensing light. The lower corners of the triangle head are formed by the auricles the planaria use for touch and detection of some chemicals dissolved in the water. From the ventral side of the planaria projects a tube known as the pharynx. It is this tube that the planaria attach to a food source at feeding time. Planaria secrete a digestive enzyme out through the pharynx to dissolve the food, and then suck up the loose parts into the pharynx.

Regeneration in planaria has been observed for many years. Currently scientists are looking to planaria to learn if it would be possible, in the future, for humans to undergo regeneration. One reason planaria make an ideal subject is the fact that more than 50% of their genes have some kind of human counterpart. For example, planaria contain a gene named piwi, which is used to create new, functioning stem cells, needed in regeneration. Humans have a counterpart named hiwi, which is used in sperm and egg cells as well as in stem cells that create blood cells. By learning about the planaria, we can indeed learn about ourselves.

Associated Activities

Timeline:
Day 1: Introduce planaria. Read and watch video. Discuss the need for model organisms and how they are used in research.
Day 2: Brainstorm different ways to help planaria grow. Have groups decide on a variable to try. Have students work out amounts of the variable (ex. concentration of vitamin, amount of light etc.) Teacher constructs a mini-aquarium with variations in substrate, vegetation, water current or light amount.
Day 3: Conduct research (computer based) on favorable conditions for planaria
Day 4: Distribute packets and **CUT PLANARIA ON A THURSDAY OR A FRIDAY**. Planaria take about 6 days to develop eyespots. In order to see them when they first develop, it is best not to have days 5,6,7 on a no school day.
Days 5-17: Observe planaria for signs of regeneration. Students should look for
- a positive response to food (place a small piece of food in the dish with the planaria and see if the planaria move towards it),
- a negative response to light (shine a flashlight on one part of the dish and see if planaria move away from it)
- the presence of eyespots (have students observe planaria using a magnifying glass or microscope)
- Students should also observe healthy planaria in their habitat, observing locations of planaria to determine optimal environment in terms of substrate, temperature and vegetation.
Day 18: Students present what they have found in their studies of the planaria
Day 19: Students design what they feel would be the optimal regeneration chamber for the planaria.

Days 20-32: Students test out their new designs to see how long it takes for planaria to regenerate in their new environment.

Day 33: Students present their findings.

Materials:
- Planaria
- Spring water
- Transfer pipettes (or medicine droppers with wide openings)
- Razors for cutting
- Small petri dishes
- A small aquarium with various substrates (gravel, rocks, sand) and vegetation
- Additional substances for various water additives for students to experiment with (vitamins, caffeine pills, antibacterial ointments etc.)

Lesson closure
- Students will present their final environment design to the class. They will also submit a written report that details how quickly their planaria regenerated in the designed environment as compared to a control planaria.

Assessment
- Students will be assessed on their lab report after initial testing
- Students will be assessed on their environment design

References
- Video of planaria regeneration: http://www.exploratorium.edu/imaging_station/research/planaria/story_planaria1.php
- Description of regeneration: http://express.howstuffworks.com/ask-mb-regenerate.htm
- Summary of planaria: http://people.westminstercollege.edu/faculty/tharrison/emigration/planaria.htm
- Background: http://www.exploratorium.edu/imaging_station/research/planaria/story_planaria.pdf
Summary

In two parts, students study the regeneration of planaria. Students begin by testing one water additive in three different concentration amounts to determine if the substance affects the speed of regeneration. Students also observe an aquarium with healthy planaria to determine planarian preference of other surroundings. Students then take what they have observed and learned to create the perfect regeneration environment for planaria.

Engineering Connection

Engineering design process

Engineering Category

Biomedical Engineering, tissue regeneration, stem cell research

Owner, Contributors, Copyright

RET Teacher    Anastasia Padilla
School          Chocksett Middle School
Town/District   Sterling, MA/Wachusett Regional School District
Introduction

The Engineering and Empathy course is designed to...

- Introduce students to the engineering design process
- Have the students work with the EDP in mechanical engineering, structural engineering, and computer engineering.
- These concepts will be presented under the umbrella of rehabilitation engineering in order to motivate the students and optimize their efforts.

Teaching Objectives and Constraints

Grade Level: 7th (appropriate for 5-8)
Lesson Duration: 7 class periods (55 minutes each)

Problem Statement:
Design a teaching unit that will assist students in understanding that there are 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 fit into a module design for the Engineering and Robotics Class.

Objectives/Functions:
- The lesson will be organized in a module style to fit into the design of the Robotics and Engineering class.
- The module will focus on biomedical engineering.
- The module will provide the students with an opportunity to work through the engineering design process.

Constraints:
- The lesson must utilize the engineering design process.
- The lesson must fit into a module design, with limited teacher direction.
- The module must have a duration of no more than 7-8 (55min.) class periods.
- The module needs to accommodate 8-10 of the 24-28 students at a time.
- The module needs to be appropriate for seventh grade students.

Research/Background

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.
3. Computer Engineering: Design a portable wheelchair ramp able to withstand the weight of the client and the wheelchair plus an assigned safety factor of three.

Engineering and Empathy Course

Each student will complete three biomedical engineering modules.

| Module #1 | Off-road Wheelchair: |
| Students Introduction: You work for an engineering start-up company, specializing in making outdoor sporting equipment. Your company has recognized that many people who are confined to wheelchairs would enjoy outdoor activities such as light hiking or even mountain biking. Your role will be to develop an off-road wheelchair that will allow this end user access to these formerly inaccessible outdoor activities.

| Module #2 | Automatic Floor Cleaner Computer Program: |
| Students Introduction: You work for a robotics and computer engineering company as an outside consultant. Your newest assignment is to create the computer program to control the movements of their newest assistive device. You will use the Lego NXT “basic car” robot to test and demonstrate your program.

| Module #3 | Portable Wheelchair Ramp: |
| Students Introduction: Your best friend has recently lost the ability to use his/her legs and now relies on a wheelchair for mobility. He/she has had ramps added to their house to allow easy access, but it is very difficult for your friend to visit your homes and the homes of his/her other friends where ramps have not been permanently installed.

<table>
<thead>
<tr>
<th>Day</th>
<th>Lesson</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduce students to the set up and grading of the class. Introduce course process</td>
</tr>
<tr>
<td>2</td>
<td>Introduce students to the field of engineering and the engineering design process. Begin whole class engineering challenge</td>
</tr>
<tr>
<td>3</td>
<td>Whole class engineering challenge continued</td>
</tr>
<tr>
<td>4</td>
<td>View Bike My Way, By Miguel GironIMO, and Dale Kruse (9 min.). In the School of Engineering and Computer Science, University of Washington (9 min.). In the Frontline of Change. Post</td>
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<tr>
<td>5-11</td>
<td>Module 1</td>
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<tr>
<td>12</td>
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<td>Module 3</td>
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<td>29</td>
<td>Flex Day</td>
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<tr>
<td>30</td>
<td>Post Test and Engineering Career Poster Viewing</td>
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</tbody>
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Assessment

- Activity Packets: This portion of the modules will function as assessments for the student’s ability to follow the engineering design process while creating their assistive devices.
- Prototypes: The student’s ability to demonstrate methods of representing solutions to a design problem will be assessed with the prototypes of their designs.
- Engineer Poster: This engineering career poster is designed to introduce the students to the career possibilities and requirements related to the science of engineering.
- Course Assessment: This end of unit test will be identical to the pre-test. This will provide data of both individual student and whole class growth. The test will contain concepts about the engineering design process as well as other related vocabulary words and concepts.

Conclusions and Future

Conclusion: Students who complete this course should be able to...
- Identify and describe the parts of the Engineering Design Process
- Utilize the Engineering Design Process for the design of their 3 products.
- Explain the reasons for their selected designs and material choices.

Future Plans: This unit will be piloted with two Engineering and Robotics classes during the first trimester of the 2010-2011 school year.

Acknowledgements

Thank you to the WPI/RET faculty and staff including... Assistive Device Mentor: Professor Allen Hoffman, Ph.D. Independent Assessor: Jeanne Hubelbank Ph.D.

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Curriculum Unit and Assessment Plan

Engineering and Empathy: Teaching Engineering through Assistive Devices

RET Project Connection

The Engineering and Empathy curriculum connects with my RET project on a very basic level. As with all engineering, the students will be working with the engineering design process, but the students will be using the EDP as it applies to assistive devices. During the Engineering and Empathy course, the students will create three products; an off road wheelchair, a computer program for an automatic floor sweeper, and a portable wheelchair ramp. All three of these learning modules use standard engineering design problems, but each one portrays the design problems in a different way. In place of designing a bicycle, the students will design an off-road wheelchair. In place of designing a computer program for the Lego robot, the students will design a computer program to control an automatic floor cleaner for the elderly. In place of designing a bridge, the students will design a portable wheelchair ramp. All three of these projects will expose the students to the same concepts that their traditional counterparts would teach, but by accessing the student’s empathy for other people, the projects become more real and the students will become more invested.

Subject Area Technology Engineering (Engineering Design Process, Biomedical Engineering, Computer Engineering, Mechanical Engineering, Structural Engineering)

Key words/Vocabulary
Biomedical engineering, computer engineering, structural engineering, mechanical engineering, wheelchair ramp, wheelchair, adaptive device, universal design, robot automation, structural engineer, engineering design process
Grade Level 7 (appropriate for 5-8)
Time Required 30 X 55 minute class periods

Learning Objectives
At the end of the module the students will be able to...
• Identify and describe the parts of the Engineering Design Process
• Utilize the Engineering Design Process for the design of their three products.
• Explain the reasons for their selected designs and material choices

Prerequisite knowledge
Prior to the start of the three modules, the students should have been introduced to the engineering design process and recognize that the process works in a circular fashion rather than a linear process with a beginning and an end.

Educational Standards
Content Standard T2.1:
• Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.

Content Standard T2.2:
• Demonstrate methods of representing solutions to a design problem (e.g., sketches, orthographic projections, multiview drawings).

Content Standard T7.1:
• Explain examples of adaptive or assistive devices, e.g., prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces.

Content Standard T1.1:
• Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, adhesives) based on specific properties and characteristics (e.g., strength, hardness, and flexibility)

Introduction/motivation
People with physical disabilities are faced with many challenges. Not only do they need to overcome the physical challenges presented by their disability, but they are also forced to deal with the perception of “being different.” As a society we have been making great strides in helping all people feel a sense of belonging and purpose regardless of their physical abilities. The engineering community has developed many assistive devices to help people with disabilities live...
a life that is as independent and as “normal” as possible. According to Medicine.net, an Assistive device is “Any device that is designed, made, or adapted to assist a person perform a particular task. For example, canes, crutches, walkers, wheelchairs, and shower chairs are all assistive devices.”

Whether the assistive device is very advanced, like a prosthetic foot for running, or very basic, like a grab bar for the shower, is irrelevant. These devices were designed by engineers to help all members of our community feel as “normal” as possible.

Lesson background and concepts for teachers

The Engineering and Empathy Course will take place during a 55 minute Engineering and Robotics Class that meets every other day for one trimester (a total of 30 class periods). During this course the students will start off with a pretest to establish what they already know. The students will then be introduced to the major parts of the engineering design process and some of the roles engineers play in our world. Following the introduction to the EDP, the students will be teamed up with one or two other students. Each student team will spend approximately seven days working on one module (an engineering project from one field of engineering). After seven days the student teams will move onto their next engineering design project. This pattern will repeat until the students have completed all three modules. The three learning modules focus on different fields of engineering, but they all share the common theme of biomedical engineering through the design of assistive devices. In addition to the three modules that the students are completing during the class time, they will be creating a poster about one field of engineering, designed to introduce the students to the career possibilities and requirements related to the science of engineering.

Tools for helping people with physical challenges have been around for as long as society has recognized that a person may need help. When renowned anthropologist, Margaret Mead, was asked about which discovery signifies the development of civilization, she did not refer to arrow heads or some other tool. For her, the discovery that showed the development of a civilization was the discovery of a human femur bone that had been broken and then healed. This is a very powerful discovery because, based on the laws of nature, an animal with a broken femur bone is sure to die. The fact that the broken bone healed, shows that other humans took care of the injured person. They showed compassion for another human (http://www.holyspiritchurch.org/about-us/homilies/true-civilization). This same compassion is what drove people to create the first eye glasses, the ear trumpet, and the wheelchair.

The history of the first assistive device is difficult to determine. Who knows when Captain Hook really received his prosthetic hand, or when Peg-leg Pete received his cellulos based artificial leg. Throughout history people have been
developing devices, to help people with disabilities that have become a benefit to us all. In 1808 the first typewriter was built by Pellegrino Turri to help a blind friend write more legibly (http://www.albritton.us/AThistory.html), and in 1920 Harvey Fletcher developed the first hearing aids which eventually lead to today’s public address systems. (http://www.albritton.us/AThistory.html)

Today, assistive devices are as varied as the people who use them. Today’s assistive technology “can include mobility devices such as walkers and wheelchairs, as well as hardware, software, and peripherals that assist people with disabilities in accessing computers or other information technologies. For example, people with limited hand function may use a keyboard with large keys or a special mouse to operate a computer, people who are blind may use software that reads text on the screen in a computer-generated voice, people with low vision may use software that enlarges screen content, people who are deaf may use a TTY (text telephone), or people with speech impairments may use a device that speaks out loud as they enter text via a keyboard” (http://www.washington.edu/accessit/articles?109).

Our technological knowledge base is increasing at an astonishing rate. With this increase in knowledge there is also an increase in the quality, design and access to assistive devices. As the number of injured soldiers increases, the government has increased its investment into resources for the development of assistive devices designed for these soldiers. Dean Kamen, known for the development of the Segway, has been funded by the U.S. government to create a new prosthetic arm to assist soldiers who have been injured during combat. Kamen “set out to reinvent the prosthesis that has been pretty much the same since the U.S. Civil War. Until now, a state-of-the-art prosthetic arm has meant having up to three powered joints. However, since this type of arm is frustrating to control and doesn’t provide that much functionality, most users still opt for the hook-and-cable device which has been around for over a century. In either case, these prosthetics only have three degrees of freedom—a user can move the elbow, the wrist, and open and close some variant of a hook” (http://spectrum.ieee.org/biomedical/bionics/dean-kamens-luke-arm-prosthesis-readies-for-clinical-trials). Kamen’s Luke Arm, which is leaps and bounds ahead of its predecessors, would be more at home on the terminator than on Captain Hook. The Luke Arm allows an almost infinite range of motion and a much smoother operation.
These Assistive technologies “should be popularized and widened in scope to assist and help disabled individuals, not only to be independent, but also to give them the chance to let out their talent and creativity and contribute to the world.” (http://www.buzzle.com/articles/history-of-assistive-technology.html)

**Associated Activities**

**Course Timeline**

Day 1: Introduce students to the set up and grading of the class.
Administer course pre-test

Day 2: Introduce students to the field of engineering and the engineering design process
Begin engineering challenge

Day 3: Whole class engineering challenge continued

Day 4: View Kiss My Wheels, By Miguel Grunstein and Dale Kruzic (56 min.)
or Not on the Sidelines Living and Playing with a Disability, By Ben Achtenberg & Karen McMillan (26 min.)
or Wheels of Change, Frontline

Day 5-11: Module 1
See descriptions below

Day 12: Flex day

Day 13-19: Module 2
See descriptions below

Day 20: Flex Day

Day 21-28: Module 3

Engineering and Empathy: Teaching Engineering Through Assistive Devices
Day 29: Flex Day

Day 30: Post-test and Engineering Career Poster Viewing

Engineering Challenge
Description: Each student team (4-5 students) is given the problem statement “create a device to make your ping-pong ball travel 1.5 meters and go into the net. The force applied to the ping-pong ball needs to be asserted by the device, not a student. You may use only the material provided for you.” The students should spend the first day creating a design plan. When the students meet for the second day they should share their plan/plans with their team, and as a group determine which design to build and test. The instructor should conference with the students as they build and test their design. A whole class debriefing should be done at the conclusion of the class.

Materials:
- Ping-pong ball (1 per team)
- Masking tape (1 roll per team)
- String (10ft. per team)
- Plastic spoon (4 per team)
- Film canister (4 per team)
- Pencil (6 per team)
- Plastic cup (4 per team)
- Rubber band (12 per team)
- Paper clip (12 per team)
- Mouse trap (1 per team)
Off-Road Wheel Chair Module

Description: Each student team (2-3 students) is given the off-road wheelchair activity packet. The packet will function as a step-by-step guide through the project. In the packet the students will define important vocabulary words, become familiar with the project, and record their progress as they move through the engineering design process. Each student team will be challenged with designing a wheelchair to be used for off-road mobility. The intended purpose would be for light hiking or mountain biking, but the design could prove to have a more humanitarian application in less developed regions of the world, where a traditional wheelchair does not work well. The student teams will need to create a simple prototype from cardstock and drinking straws. The prototypes will be tested on simulated surfaces using a spring scale to measure the force needed to move the wheelchair.

Materials:

- Activity Packet (1 per student)
- Cardstock
  - Sheets
  - 1cm strips
- Drinking Straws
- Hot glue gun (1 per student team)
- Hot glue
- Scissors (1 per team)
- Ruler (1 per student)
- Measuring tape
- Circle template (1 per team)
- Graph paper
- Model of client for measurement
Portable Wheelchair Ramp Module

Description: Each student team (2-3 students) is given the portable ramp activity packet. The packet will function as a step-by-step guide through the project. In the packet the students will define important vocabulary words, become familiar with the project, and record their progress as they move through the engineering design process. Each student team will be challenged with designing a portable wheelchair ramp. The intended purpose would be to allow wheelchair access to houses and other buildings that are not handicap accessible. The ramp will need to be light weight and portable, but also strong enough for the intended use. The student teams will need to create a simple prototype from cardstock, cardboard, paper and drinking straws. The prototypes will be tested for ramp weight and applied load.

Materials:
Activity Packet (1 per student)
Cardstock
   Sheets
   1 cm strips
Cardboard
   1 cm strips
   2 cm strips
Printer Paper
Drinking straws
Hot glue gun (1 per team)
Hot glue
Weights to test ramp strength (1 set)
Graph paper
Ruler (1 per students)
Automatic Floor Cleaner Module

**Description:** Each student team (2-3 students) is given the automatic floor cleaner program activity packet. The packet will function as a step-by-step guide through the project. In the packet the students will define important vocabulary words, become familiar with the project, and record their progress as they move through the engineering design process. Each student team will be challenged with designing a computer program to operate an automatic floor cleaner. The intended purpose would be for the elderly. Many elderly people have deteriorating eye sight and coordination. The combination of these two traits can result in food and other debris falling to the floor, remaining there unnoticed. The automatic floor cleaner will function as an assistive device to clean the food particles and other debris from the floor before the vermin and other pests become enticed into the home. The student teams will need to create the program using the Lego NXT platform. The prototypes will be tested using the Lego “Basic Car” as a simulated floor cleaner.

**Materials:**
- Activity packet (1 per student)
- Lego NXT student kit (1 per team)
- Computer access (1 station per team)
- Electrical tape

Lesson closure

The engineering with a purpose program will end with the students creating an 11x17 poster about 1 field of engineering. The student poster will include:

- Clear tile
- What the engineer does
  - Examples of the type of work
  - What the world would be like without the engineer
- Required college education
  - Schools with the desired major
  - Requirements for the school and major
- Possible careers within the field
  - Pay scale
  - Real world example of a job advertisement for the engineer
Additional multimedia support

- [http://www.youtube.com/watch?v=7NJvgT60-mk&feature=fvw](http://www.youtube.com/watch?v=7NJvgT60-mk&feature=fvw), Wheel Chair back-flip
- [http://www.youtube.com/watch?v=sPSf517Gvd0](http://www.youtube.com/watch?v=sPSf517Gvd0), Off road chair for yard work, hunting, and fishing
- [http://www.youtube.com/watch?v=yr8d9QAc5RQ](http://www.youtube.com/watch?v=yr8d9QAc5RQ), Katie bot III, extreme mobility wheelchair
- [http://www.youtube.com/watch?v=lCwSi_14S2E&feature=related](http://www.youtube.com/watch?v=lCwSi_14S2E&feature=related), 4wd wheelchair
- [http://www.youtube.com/watch?v=7s4YvLag1zk&feature=related](http://www.youtube.com/watch?v=7s4YvLag1zk&feature=related), Track drive wheelchair
- [http://www.youtube.com/watch?v=w9asMwsjKjM](http://www.youtube.com/watch?v=w9asMwsjKjM), Ramps evaluated by wheelchair users
- [http://www.youtube.com/watch?v=V_wWxbmqm6Q&NR=1](http://www.youtube.com/watch?v=V_wWxbmqm6Q&NR=1), Modified SUV w/ ramp
- [http://www.youtube.com/watch?v=GiABoCn60yo&feature=related](http://www.youtube.com/watch?v=GiABoCn60yo&feature=related), rolling portable ramp

Assessment

For the purpose of this program, the students will be assessed on their ability to accurately use the engineering design process as well as their ability to accurately represent their designs using multi view drawings and scale models or prototypes. The course will utilize both formative and summative means of assessment to evaluate the students.

**Formative Assessments:**

**Pre-assessment**- prior to the start of the unit the students will complete a pre-test. This pre-test will function as a tool to determine if curriculum compacting is necessary, and it will also function as a baseline to determine student growth during the unit.

**Vocabulary assignments**- the students understanding of the vocabulary can be assessed based on the sentences that they create to accompany the vocabulary definitions.

**Off-road wheelchair activity packet**- This portion of the module will function as a formative assessment for the student’s ability to follow the engineering design process while creating their off road wheelchair.

**Wheelchair Drawing/Prototype**- The student’s ability to demonstrate methods of representing solutions to a design problem will be assessed with the drawings and prototype of their wheelchair designs.

**Portable Ramp activity packet**- This portion of the module will function as a formative assessment for the student’s ability to follow the engineering design process while creating their portable ramp.
**Portable ramp drawing/Prototype**- The student’s ability to demonstrate methods of representing solutions to a design problem will be assessed with the drawings and prototype of their portable ramp.

**Automatic floor sweeper activity packet**- This portion of the module will function as a formative assessment for the student’s ability to follow the engineering design process while creating their portable ramp.

**Floor sweeper program prototype**- The student’s ability to demonstrate methods of representing solutions to a design problem will be assessed with the drawings and prototype of their floor sweeper program.

**Engineer Poster**- This engineering career poster is designed to introduce the students to the career possibilities and requirements related to the science of engineering.

**Summative Assessments:**

**Course assessment** - This end of unit quiz will be identical to the pre-test. This will allow a picture of student growth or class growth using the mean quiz scores. The quiz will contain material about the engineering design process as well as important vocabulary words.

**Off road wheelchair activity packet**- This portion of the module will function as a summative assessment for the student’s ability to accurately use engineering design process to create their wheelchair design.

**Portable Ramp activity packet**- This portion of the module will function as a summative assessment for the student’s ability to accurately use engineering design process to create their portable ramp design.

**Automatic floor sweeper activity packet**- This portion of the module will function as a summative assessment for the student’s ability to accurately use engineering design process to create their floor sweeper program design.
Lesson #1 of 1

Summary

The engineering with a purpose program is designed to allow students to further their understanding of the engineering design process (EDP) while being introduced to assistive devices and biomedical engineering. During the 3 modules (7 X 55min. each) the students will be given a fictional client statement and will then be required to follow the steps of the EDP to design the product (off-road wheelchair, floor sweeper computer program, portable wheelchair ramp). In addition to the, students will need to identify appropriate materials and demonstrate two methods of representing solutions to their design problem (scale drawings and simple prototypes).
Engineering Connection

Engineering design process

Engineering Category

Biomedical Engineering, mechanical engineering, computer engineering, structural engineering

Attachments

Engineering Challenge Packet pp. 14-15
Automatic Floor Cleaner Program pp. 16-25
Portable Wheelchair Ramp Packet pp. 26-34
Off-road Wheelchair Packet pp. 35-42

Owner, Contributors, Copyright

RET Teacher Jared R. Quinn
School Overlook Middle School
Town/District Ashburnham, MA/ Ashburnham-Westminster Regional School District
Date:

Name:

Class:

Define the following terms:

Engineering Design Process:

Problem Statement:

Function:

Constraint:

Objective:
Define the following terms.

Robot:

Robotics:

Computer Engineering:

Construction:

Use the NXT directions to build the "basic car" robot.
Programming:

Use the Lego NXT 2.0 program to create a program for each of the following tasks. Make sure each program has a clear title including your initials, e.g. JO SQUARE, JO LINE, JO CIRCLE.

1. Drive in a straight line for 2 feet.
2. Drive in a straight line for two feet, turn around and return.
3. Trace the square marked on the floor.
4. Follow the irregular line on the floor.
5. Drive in a smooth circle (+10 Bonus)

Introduction:

You work for a major robotics and computer engineering company as an outside consultant. Your newest job is to create the computer program to control the movements of their new assistive floor cleaner. You will use the Lego NXT “basic car” robot to test and demonstrate your program.

Client Statement:

Many elderly people develop a variety of vision problems as they age. With diminished eye sight a number of problems arise. The cleanliness of the home being one of these problems. We have developed a very small self-contained floor cleaner. Our vision is to have the cleaner be able to move around the room in a random pattern, while using sensors to avoid running into furniture, pets and other obstacles in the room. This random pattern will allow the “robot cleaner” to essentially clean the entire floor if given enough time.

Problem Statement: (Define the problem in detail)

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________
Constraints: (The product must or must not)


Background research:

For homework use the internet to research; robotics, computer programs, existing products that carry out similar functions, computer programs that control robot movements, robotic automation, and other related topics. Make sure to keep a record of relevant material and the website(s) you used for research.

Research completed: __________________________

Date Teacher
Test Results (describe the test results in detail)

Evaluation of Results (based on the results, what worked, what didn't work)
<table>
<thead>
<tr>
<th>Date:</th>
<th>Structural Engineering:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td>Define the following terms:</td>
</tr>
<tr>
<td>Class:</td>
<td>Structural Engineering:</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.nationalgeographic.com/science/article.cfm?AID=1377331&amp;CFID=1377331&amp;CNID=1377331">http://www.nationalgeographic.com/science/article.cfm?AID=1377331&amp;CFID=1377331&amp;CNID=1377331</a></td>
</tr>
<tr>
<td></td>
<td>Assistive Devices:</td>
</tr>
</tbody>
</table>
Introduction:

Your best friend has recently lost the ability to use his/her legs and now relies on a wheelchair for mobility. Her/his parents have had ramps added to their house to allow easy access, but it is very difficult for your friend to visit your home and the homes of his/her other friends where ramps have not been permanently installed.

Client Statement:

You need to create a portable ramp that can make typical houses and other buildings temporarily handicap accessible. The ramp should be light, easy to transport, easy to operate, safe and versatile.

Problem Statement: (Define the problem in detail)

Revised Problem Statement: (Definition of the problem in detail including client modifications)
Functions: (what the product does)

Objectives: (What the product is)

Constraints: (The product must or must not)
Background research:

For homework use the internet to research; current wheelchair ramp designs, wheelchair ramp standards, ramp materials, and other related topics. Make sure to keep a record of relevant material and the website(s) you used for research.

Research completed: ________________________________  ________________________________

Date  Teacher:
Creation of Prototype (describe why you chose the design you did)


Test Design

1. Place the ramp prototype between two desks.
2. Use the load applicator strap to apply increasing weights to your ramp.
3. Apply weight to the middle of the ramp until the device holds the minimum required weight based on the problem statement.
4. Use the video camera to record your test

Test Results

(Description of test results)


Name: ___________________________  Date: ________________
Class: __________________________ Mechanical Engineering

Define the following terms

Mechanical Engineering:
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

Bioengineering:
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

Biomedical Engineering:
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

Introduction:

You work for an engineering start-up company, specializing in making outdoor sporting equipment. Your company has recognized that many people who are confined to wheelchairs would enjoy outdoor activities such as light hiking or even mountain biking. Your role will be to develop an off-road wheelchair that will allow this end user access to formally inaccessible outdoor activities.
Client Statement:
You need to create an off-road wheelchair for recreational purposes. The wheelchair should be easy to transport and operate, and be effective in traversing off-road terrain, such as trails, fields, and beaches.

Problem Statement: (Define the problem in detail)

Revised Problem Statement: (Definition of the problem in detail including client modifications)

Functions: (what the product does)
Objectives: (What the product is)

Constraints: (The product must or must not)

Background research:

For homework use the internet to research; past and present wheelchair designs, off road and mountain bikes, why people need wheelchairs, and other related topics. Make sure to keep a record of relevant material and the website(s) you used for research.

Research completed: Date ___________________________ Teacher ___________________________
**Creation of Prototype** (describe why you chose the design you did)

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

**Test Design**

1. Attach the scale model of wheelchair design to the spring scale.
2. Pull your wheelchair across the 3 simulated off-road surfaces.
3. Record the highest amount of force needed to move your model at any point during each movement simulation.
4. Record your data in the table.
<table>
<thead>
<tr>
<th>Test Results</th>
<th>(Complete the table and record the test results in detail)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>Beach, Light Hike, Field</td>
</tr>
<tr>
<td>Trial 2</td>
<td></td>
</tr>
<tr>
<td>Trial 3</td>
<td></td>
</tr>
<tr>
<td>(Record measured information)</td>
<td>Description of results</td>
</tr>
</tbody>
</table>
Evaluation of Results (Was your design effective? How do you know?)

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Future Recommendations (What you would recommend for future research)

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

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______________________________________________________________________
Maintaining Health in Space
Suzanne R. Smith
Kennedy Middle School, Natick MA

WPI-NSF RET Program in Bioengineering, Worcester Polytechnic Institute, Worcester, MA

Introduction

• Design of Curriculum Unit: Reinforce standards assessed on the 8th grade Massachusetts Comprehensive Assessment System (MCAS) Science, Technology and Engineering exam, through a kinesthetic approach, utilizing the Engineering Design Process (EDP).
- Massachusetts does not have a review protocol to prepare for the MCAS exam
- Current exam preparation consists solely of reviewing old questions
- Challenging to recall vast amount of important concepts from multiple science and engineering courses
- Variation exists in students exposure to technology and engineering courses

Teaching Objectives and Constraints

Problem Statement: Create a curriculum unit to teach an aspect of biomedical engineering utilizing the Engineering Design Process. The unit should align with the standards set forth in the Massachusetts Science/Technology and Engineering Curriculum Frameworks.

• Objectives:
  - Introduce the engineering design process and its application to science and medicine.
  - Reinforce concepts in physical, life and earth sciences to improve student understanding and knowledge retention.
  - Increase student's kinesthetic experiences in the classroom.
  - Develop students' communication abilities.
  - Develop students' team-work skills.
  - Inspire students to incorporate engineering based problem solving skills in their daily lives.

• Constraints:
  - Time allocation- must be taught during enrichment period
  - Diverse learning styles in the classroom
  - Limited resources
  - Varying backgrounds in science and technology experience
  - Massachusetts DOE standards and frameworks

• Topics covered: Physical Science, Earth Science, Life Science, Technology, Engineering and Mathematics

• Student grade: 8th grade Earth Science

• Numbers of students: 50 students (25 per class) working in groups of 2-3

• Number and duration of class periods: Approximately 21 weeks, 2 times per week for 45 minutes

Research/Background

1. Design a space suit for use by astronauts to protect them from radiation and extreme temperatures.
2. Design a shoe that could be used in space to help keep astronauts secured to the spacecraft and also mimic gravity.
3. Create a device to help prevent the circulation problems and motion sickness astronauts face during their first days in space.
4. Design an exercise device that could be used in space to combat bone loss and muscle atrophy.

Chosen Solution

• Solution: Create an exercise device that could be used in space to combat bone loss and muscle atrophy.

• Objectives:
  - Students will review and be able to apply the EDP to a real life problem
  - Students will reacquaint themselves with concepts in life science relating to adaptations, body systems and the hierarchical organization of multicellular organisms
  - Students will be able to describe the relationship between gravity and weight and how it changes in regards to properties of the solar system
  - Students will be able to differentiate between mass and volume and define density

• Constraints:
  - Device must be appropriately scaled for use by a student
  - Device should be able to engage multiple muscle groups
  - Device should not weigh more than 5 lbs
  - Device must provide intrinsic resistance

• General Project Timeline:
  - MCAS pretest, Intro to EDP, Preconceptions, Expectations
  - Astronauts in Space, What students already know, Space Station movie
  - Human physiological adaptations to Space, Focus: Bone Loss/Muscle Atrophy
  - Research what currently exists to combat problems in space, Share findings
  - Body area assigned, Brainstorm possible movements, Utilize skeletons
  - Consult with Fitness Instructor for questions, Solidify possible designs
  - Decide on best design, Create presentation for class about design
  - Presentations, Class gives feedback and ideas
  - Construction of prototype
  - Testing and evaluating prototype, Prepare update for class
  - Redesign Process
  - Create and deliver final presentations of the project incorporating the EDP
  - Reflecting on the project and the EDP
  - Post testing MCAS/ Re-evaluation of perceptions of engineering
  - Engineering as a career choice (trading cards)

Assessment

Using formative assessment students will be checked daily to determine if they are attaining milestones in the project, both in understanding and Engineering/Design process.

At project completion students will be reassessed on the curriculum standards included in the project through a retest of the initial MCAS review exam given prior to the start of the project. A pairwise comparison will be done using the data obtained from these exams.

Attitudes towards engineering, confidence in their ability to use the EDP, and consideration of engineering as an attainable career will be assessed before and after the project using a survey.

Conclusions and Future

• Conclusions:
  - The EDP can be utilized daily in the middle school setting as a means to problem solve.
  - The EDP can be naturally and easily applied to a variety of existing curriculums.
  - The RET program is an invaluable tool for supporting educators in implementing engineering in the classroom.

• Future:
  - It is my hope that students:
    - Improve Science MCAS scores and areas of weakness
    - Consider the EDP in their everyday lives as a way to problem solve
    - See engineering as an attainable career possibility
  - I envision using this project yearly as a way to better prepare my students for their MCAS exams

Acknowledgements

• Enormous thanks to:
  - Principle Investigators: Drs. Glenn Gaudette and Ray Page
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Curriculum Unit and Assessment Plan

Maintaining Health in Space: Creating an exercise device to prevent bone loss and muscle atrophy during space flight

RET Project Connection

I worked in Professor Glenn Gaudette’s laboratory at WPI in the Biomedical Engineering Department on a project utilizing fibrin micro-threads. The goal of the project was to use the Engineering Design Process (EDP) to create a device that would improve the current process of bundling threads for suture preparation. The sutures are then used to deliver stem cells to the myocardium in an effort to initiate myocardial regeneration in areas of the heart damaged by infarction. It is hypothesized that regeneration of this tissue post infarction would lead to a recovery of function thereby improving cardiac output and efficiency. This project directly relates to the curriculum unit I developed as it takes students through the EDP to solve a problem pertaining to human health.

Subject Area
Middle School Science, Earth Science, Physical Science, Life Science, Math, Engineering and Technology

Key words/Vocabulary
astronaut, nasa, design, engineering, gravity, exercise, middle school, muscle atrophy, osteoporosis, biomedical engineering

Grade Level
Middle School 7th, 8th

Time Required
Approximately 21 weeks, 2 meetings per week for 45 minutes each

Learning Objectives

- Increase student’s knowledge of the EDP and its application to science and medicine.
- Reinforce scientific and technologic concepts in order to improve student understanding and knowledge retention.
- Increase student’s kinesthetic experiences in the classroom.
- Develop student’s ability to communicate.
WPI-NSF RET in Bioengineering Design in the Middle School Classroom

- Develop student’s team-work skills. Students will review and be able to apply the EDP to a real life problem
- Students will reacquaint themselves with concepts in life science relating to adaptations, body systems and the hierarchical organization of multicellular organisms
- Students will be able to describe the relationship between gravity and weight and how it changes in regards to properties of the solar system
- Students will be able to differentiate between mass and volume and define density

Prerequisite knowledge

Students should have a basic middle school level knowledge and understanding of topics in physical, life and earth sciences (For specifics please see educational standards). Some students may have experience with engineering and technology however it is not a requirement.

Educational Standards

In compliance with Massachusetts State Frameworks:

Earth and Space Science- The Earth in the Solar System

Learning Standard 8:
Recognize that gravity is a force that pulls all things on and near the earth toward the center of the earth. Gravity plays a major role in the formation of the planets, stars, and solar system and in determining their motion.

Learning Standard 10:
Compare and contrast properties and conditions of objects in the solar system (i.e., sun, planets, and moons) to those on Earth (i.e., gravitational force, distance from the sun, speed, movement, temperature, and atmospheric conditions).

Life Science - Structure and Function of Cells

Learning Standard 2:
Recognize that all organisms are composed of cells, and that many organisms are single-celled (unicellular), e.g., bacteria, yeast. In these single-celled organisms, one cell must carry out all of the basic functions of life.
Life Science- Systems in Living Things

**Learning Standard 5:**
Describe the hierarchical organization of multi-cellular organisms from cells to tissues to organs to systems to organisms.

**Learning Standard 6:**
Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination) and describe ways that these systems interact with each other.

Life Science- Evolution and Biodiversity

**Learning Standard 12:**
Relate the extinction of species to a mismatch of adaptation and the environment.

Physical Sciences- Properties of Matter

**Learning Standard 1:**
Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.

**Learning Standard 2:**
Differentiate between volume and mass. Define density.

Physical Sciences- Elements, Compounds and Mixtures

**Learning Standard 7:**
Give basic examples of elements and compounds.

Technology and Engineering- Materials, Tools and Machines

**Learning Standard 1:**
*Central Concept:* Appropriate materials, tools, and machines enable us to solve problems, invent, and construct.
Technology and Engineering- Engineering Design
Learning Standard 2:
Central Concept: Engineering design is an iterative process that involves modeling and optimizing to develop technological solutions to problems within given constraints.

Technology and Engineering- Communication Technologies
Learning Standard 3:
Central Concept: Ideas can be communicated through engineering drawings, written reports, and pictures.

Technology and Engineering- Bioengineering Technologies
Learning Standard 7:
Central Concept: Bioengineering technologies explore the production of mechanical devices, products, biological substances, and organisms to improve health and/or contribute improvements to our daily lives

Introduction/motivation

Students in their 8th grade year of science face the daunting task of succeeding on the Massachusetts MCAS Science and Technology examination which encompasses three years of their middle school science experiences as well as technology and engineering. This is challenging for them as they need to be able to recall important concepts from three different fields of science, two of which they have not reviewed in 2 or more years. Massachusetts currently does not have in place a review plan for these 8th graders to prepare them sufficiently for the exam. In years past, exam preparation for 8th graders has solely focused on reviewing old MCAS examination questions. Although this is valuable, research has shown that students learn and retain much more if movement tactile experiences are involved.

In this unit my goal was to create a project that would reinforce important science standards from all tested fields through a kinesthetic hands-on approach. In this way the students would gain a valuable review of concepts while engaged in a project. Not only would the project allow them to be creative, it would take them through the steps of the EDP which is highly tested on MCAS. The unit would also apply the knowledge I have gained through my summer research experience at WPI in the field of Biomedical Engineering.
Astronauts face many physiologic changes when they enter the zero gravity environment of space. Motion sickness, alterations in circulation and weightlessness are only a few of the changes they experience. Perhaps the most important changes however are muscle atrophy and loss of bone density. Bone and muscle are living tissues and therefore require stresses to keep them strong. Periods of immobility and the added component of weightlessness in space compound the problem of maintaining this strength in astronauts.

Although the muscle mass lost during space flight can typically be regained, the loss of bone density cannot be completely reversed. The density of bone in the skeletal system is important for many reasons as the system provides the architecture of the human body. When this support system becomes weakened by a loss of density, it can have a substantial impact on an individual’s life and overall health. Upon their return to Earth they are at an increased risk for fractures, nerve impingement and pain, all of which can be further debilitating.

One way to prevent muscle atrophy and bone loss is to exercise regularly. Exercise provides the important stresses that the muscular and skeletal systems need to maintain their strength. In an effort to counter this loss in space and prevent the problems astronauts face once they return to Earth, exercising in space has become crucial. Here on Earth exercise is relatively simple because our planet facilitates the necessary stresses through gravity. The problem for astronauts in space is that there is no gravity, so the environment does not lend itself to traditional forms of exercise. Running on a treadmill for example becomes a very awkward process because the astronaut is unable to stay on the machine unless they are strapped in.

Currently research is being done to determine the best ways to provide astronauts with the exercise they need while in space. As previously mentioned, in a weightless environment the challenge becomes creating a force to simulate gravity or provide resistance. There are however other challenges including the fact that any exercise machinery or apparatus brought into space, needs to be lightweight and compact.
Associated Activities

General Timeline: Note – this can be adjusted to fit available timeframe

Week 1: MCAS pretest, Intro to EDP, Preconceptions, Expectations
Week 2: Astronauts in Space- what students already know, Space Station movie
Week 3: Human physiological adaptations to Space, Focus: Bone Loss and Muscle Atrophy
Week 4: Brainstorming- how to combat bone loss and muscle atrophy, Research
Week 5: Research what currently exists to combat problems in space
Week 6: Research, Sharing of findings in classroom
Week 7: Body area assigned, Brainstorm possible movements, Utilize skeletons
Week 8: Consult with Fitness Instructor for questions, Solidifying possible designs
Week 9: Decide on best design, Create presentation for class about design
Week 10: Presentations, Class gives feedback, ideas
Week 11: Construction of prototype
Week 12: Testing and evaluating prototype
Week 13: Testing and evaluating prototype, Prepare update for class
Week 14: Class updates on design
Week 15: Redesign Process
Week 16: Redesign Process
Week 17: Create final presentations of the project incorporating the EDP
Week 18: Finish final drafts of presentations, Begin presenting
Week 19: Presentations
Week 20: Reflecting on the project and the EDP
Week 21: Post testing MCAS
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Materials:

Students will come up with own ideas not limited to:

Exercise Banding
Rubber Tubing
Pulleys
Springs
Webbing

Lesson closure

Presentation of device and EDP
Engineering as a Career- Trading Cards

Additional multimedia support

IMAX Space Station Video
Assessment

Using formative assessment students will be checked daily to determine if they are attaining milestones in the project, both in understanding and Engineering/Design process.

Students will be assessed on the curriculum standards included in the project through an initial practice MCAS exam given prior to the start of the project. They will be reevaluated on this exam post project and a pairwise comparison will be done using the data obtained from these exams.

Attitudes towards engineering, confidence in their ability to use the EDP, and consideration of engineering as an attainable career will be assessed before and after the project using a survey.

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Space Travel and the Effects of Weightlessness on the Human Body.

Associated Unit

N/A
Lesson #1 of 1

Lesson Dependency
N/A

Summary
This curriculum unit is designed to give students a kinesthetic review of the science, technology and engineering concepts tested on the 8th Grade Massachusetts MCAS Examination. Over the course of approximately 21 weeks, students will develop their research and presentation skills as they solve a biomedical problem using the Engineering and Design Process.

Engineering Connection
Engineering design process

Engineering Category
Biomedical Engineering

Attachments
Forthcoming

Other, Related URL
N/A

Owner, Contributors, Copyright

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Curriculum Content
Assistive Device Project

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Introduction

• Solving problems is a scientific process requiring abstract thought as well as concrete strategy. The Engineering Design Process allows students to practice and learn new skills vital for future achievement.
• Get the students to identify a need and write a problem statement.

Problem – Invention – Success

Helping to improve our way of life

• Biomedical engineering helps provide relief and encouragement to people with medical conditions and disabilities.
• Understanding what a need is and how to write a problem statement will help students solve many problems in the future.
• Students will practice effective communication skills that are essential for success. Concurrently, they will learn about tools, materials, machines, design, and manufacturing.

Teaching Objectives and Constraints

• Awareness of Biomedical engineering
• Ability to write a problem statement
• Communicate their solution verbally, audibly, visually and in written form
• Application of math and science skills (Mass, density, force, motion, friction, and gravity)
• Use structured web based research
• Student self-learning

Research/Background

Technology-Related Assistance for Individual with Disabilities Act
• 1998 (PL 100-407)-first legal definition of assistive technology devices
• An assistive technology device defined:
  • “any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities.”

Ideas:
• Sports equipment
• A device to remove / replace a broken light bulb
• A support device to aid bone healing after an injury
• A device to open a tight lid on a jar
• A device to control a car with just upper body

Curriculum Content

Chosen Solution

• To cover a number of state standards my solution is as follows:
• Curriculum Design
  • Introduce the EDP
  • Use the process to solve a simple problem
  • Encourage the students to write their own separate problem statement based on assistive devices
  • Facilitate the progress of the students though observation and guidance
  • Achieve a relevant and good quality design solution

How it is done
• 20 class unit
• First 6 classes to include a simple EDP problem. “Design a sticker to show a first responder to a motorcycle accident not to remove the helmet due to secondary injury risk”.
• Together as a class, walk the students through the EDP
• Now the students have EDP knowledge
• Task students (in groups) to write their own problem statement
• Problem MUST be an assistive device application
• Facilitate their progress and identify strong and weak areas
• Strong concentration on their communication skills

Assessment

• Using a pre and post test will demonstrate learning of the objectives.
• Survey the students to identify need for coarse improvement.
• Client or peer feedback referencing the functionality of the device.
• Does the design solution solve the their objectives?

Conclusions and Future

• Do they understand “client”, “user”, and “design”?
• Client or peer feedback referencing the functionality of the device.
• Survey the students to identify need for coarse improvement.
• At what level can they communicate their solution?
• Are they researching to support self learning?
• Has their vocabulary improved in the field of BME?
• Can they identify BME projects and careers?
• Do they understand “client”, “user”, and “design”?

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2010 RET program teachers. Seven Hill Pediatric Center, Lowell Coroporation, Bicycle Alley, WPI Manufacturing Facility, WPI Mechanical Engineering Department, WPI Robotics Department

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Biomedical engineering (BME) studies engineering concepts for biological advancement. A Biomedical Engineer uses traditional engineering expertise to analyze and solve problems in biology and medicine. Source: The Biomedical Engineering Society. The field is as old as man but has only relatively recently evolved into its own discipline. The early days of mankind presented many problems such as how to aid healing after a day's hunt or how to repair a broken bone. Modern biomedical problems seek highly technical solutions that allow the development of artificial limbs or cell growth to form new livers, hearts, and lungs. The future of BME is infinitely challenging.

Worcester Polytechnic Institute of Worcester, Massachusetts houses a rehabilitation center headed by Dr. Allen Hoffman who continuously develops solutions to aid severely handicapped people function as normally as possible. The center engineers assistive and adaptive devices that allow mobile impaired people to move around or pick things up or even to play games with their children or pets.

Many solutions exist to a single problem, some are fantastic and some are not so good. In order to arrive at the best solution it is important to maintain structure. Using the Engineering Design Process (EDP), engineers intelligently work through multiple possibilities to develop a successful and relevant solution. The EDP is always iterative; it continually asks for improvement and as such the product from the solution gets better every time.

Subject Area: Engineering Technology
Key words/Vocabulary: Engineering Design Process, Problem Statement, Specification, Assistive device, mobility, Physics
Grade Level 7th and 8th
Time Required 20 classes at 45 minutes per class

Learning Objectives
At the end of the lesson, the students will be able to:
- Adopt the Engineering Design Process to other problem solving assignments.
- Identify problems and potential improvements.
- Write a problem statement.
- Communicate technical data verbally, visually and audibly using correct terminology.

Prerequisite knowledge
- Measurement, basic math skills, basic writing skills, basic computer skills

Educational Standards

Content Standard A: Bioengineering Technologies

- 7.1 Explain examples of adaptive or assistive devices, e.g., prosthetic devices, wheelchairs, eyeglasses, grab bars, hearing aids, lifts, braces.
- 7.2 Describe and explain adaptive and assistive bioengineered products, e.g., food, bio-fuels, irradiation, integrated pest management.

Content Standard B: Engineering Design

- 2.1 Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign.
- 2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.
- 2.3 Describe and explain the purpose of a given prototype.
- 2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.
- 2.5 Explain how such design features as size, shape, weight, function, and cost limitations would affect the construction of a given prototype.
Content Standard C: Communication Technologies

- 3.2 Identify and explain the appropriate tools, machines, and electronic devices (e.g., drawing tools, computer-aided design, and cameras) used to produce and/or reproduce design solutions (e.g., engineering drawings, prototypes, and reports).
- 3.3 Identify and compare communication technologies and systems, i.e., audio, visual, printed, and mass communication.
- 3.4 Identify and explain how symbols and icons (e.g., international symbols and graphics) are used to communicate a message.

Content Standard D: Materials, Tools, and Machines

- 1.1 Given a design task, identify appropriate materials (e.g., wood, paper, plastic, aggregates, ceramics, metals, solvents, and adhesives) based on specific properties and characteristics (e.g., strength, hardness, and flexibility).
- 1.2 Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate, and explain their safe and proper use.
- 1.3 Identify and explain the safe and proper use of measuring tools, hand tools, and machines (e.g., band saw, drill press, sander, hammer, screwdriver, pliers, tape measure, screws, nails, and other mechanical fasteners) needed to construct a prototype of an engineering design.

Introduction/motivation

From the dawn of mankind, human beings have evolved with far greater success than any other species on the planet. What sets us apart from other animals? Our ability to solve problems. Early man invented spears so they could catch large prey easily and with reduced risk of being killed during the hunt. Today, engineers and scientists are consistently posed with technical problems. Where would we be if we could not solve problems? No cars, cell phones, TV etc... So how do we start solving problems? This curriculum unit enlightens you to the simple process of invention. Once you learn this process, there is nothing stopping you from being the next millionaire inventor like Bill Gates (Microsoft) or Dean Kamen (Segway).

In this unit the students will concentrate on identifying a need and writing their own problem statement. They will identify a need based on the subject of assistive / adaptive devices and will use the EDP to develop a solution.

Lesson background and concepts for teachers

Since problem solving is such a vital skill for students to practice with, our encouragement and understanding of the engineering design process is critical for their success in all academic areas. We can use the EDP to demonstrate its
importance when solving biomedical problems. There are so many physical limitations to a disabled person. An understanding of disability will drive the creation of a problem statement as well as highlight its importance.

**Associated Activities**

**Lesson Breakdown:**

1. Introduction to the 20 class project. Give them the pre-test. Explain what the following: BME, disabilities, daily functions, and rehabilitation engineering. Display the steps of the EDP and run through an example (you can use JFK’s problem statement, “Put a man on the Moon”, or alternative.

2. Give the students the following problem statement: “Design a label to show a first responder to a motorcycle accident and not to remove the helmet”. One of the worst things a first responder can do is remove the helmet of a motorcycle accident victim as this may result in secondary and more serious injuries to the victim. Use group discussion and research to refine the problem statement. Once the refined problem statement is acceptable, the students should detail the specifications to control the design solution.

3. Break the students into groups of 3 or 4 and have them brainstorm possible solutions. They should use sketches, labels, and written descriptions of their concepts. They must then select the best solution based on their specifications and *verbally* (presentation practice) explain their selection for best concept.

4. The students will finalize their design using any communication tools they chose the design must be to scale and rendered in full color. They must use *engineering text* to label their design and write a description of why it was chosen and how it will work. At this stage the teacher should be looking for relevance to the specification.

5. Test each design by peer evaluation. Each group should collect feedback, both positive and negative to document the pros and cons of their design. They must then use this feedback to make modification to their design.

6. The groups must now communicate their design solution to relevant users. Motorcycle riders, public, hospital staff, police, manufacturers and distributors of the product etc...

7. Review the process as a class and together vote for the best design. Take 15 minutes at the end of class and introduce the next part of the project. “Using the EDP, identify a need for a biomedical assistive device to aid a limited mobility individual in any daily activity.” The students can then go home a start their research (ask family and friends to help come up with an initial problem statement. Student must return to class with at least 2 problem statements.

8. Review all the problem statements, break them up into groups of 3 or 4 (same or different) and have them use the EDP to continue with their project. Give them their deliverables (project deadline 9 classes from now). As the teacher, you are free to facilitate the group work and ensure they are sticking to the EDP.
18. The students will present their solution using any communication tools they choose but must use visual, audible and written form of communication. Each group should be given 5 minutes for this.

19. Review each of the designs as a class and use peer evaluation to select a best project. The evaluation should include: Following of the EDP, most effective problem statement, function and performance, clearest communication strategy.

20. Give the post test and then review the 20 class project. Ask for feedback so the project can be re-designed where necessary; after all lesson plans are EDP friendly.

Lesson closure

At the end of the project, the students may need reminding that have directly helped to improve the life of another person.

Lesson extension activities

In order for the students to recognize the difficulties of having mobility issues; here are some suggested activities.

- Peel an orange with one arm tied around your back
- Organize a selection of nails wearing safety glasses smeared with grease
- Tie a knot in some string wearing thick gloves

Assessment

Pre-test
Students will be given a multiple choice test to establish what they understand about solving problems and the EDP

Post test
After the students have solved their own problem statement, the students will repeat the test to show increased understanding and knowledge.

Peer evaluation

Observation

References

http://www.doe.mass.edu/frameworks/current.html
http://www.disabilityproducts.com/cgi-bin/disabilityproducts.cgi
Summary

This 20 class course will guide the students through the engineering design process twice. The first 6 classes will be completed together as a class and will cover the steps of the EDP and the expectations of the teacher for successful grading. Following completion of the first example, students will generate their own problem statement and use what they have learned to provide a solution.

Engineering Connection

Engineering design process.

Engineering Category

Rehabilitation engineering

Attachments

Other, Related URL

Owner, Contributors, Copyright

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Town/District  Auburn, MA