K-6 Gets a Piece of the PIEE:

Partnerships Implementing Engineering Education

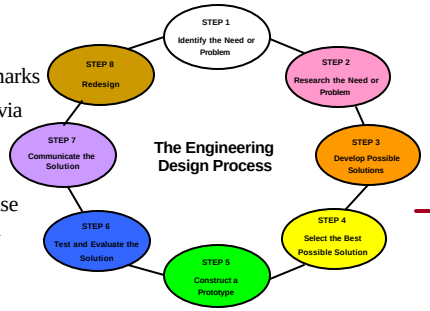
Worcester Polytechnic Institute: Judith E. Miller, PI;Joseph J. Rencis, Co-PI; John Goulet
Worcester Public Schools (WPS): Gale H. Nigrosh, Co-PI; Patricia McCullough, Principal; Ruthann R. Melancon, Principal; Patrick DeSantis, K-8 Science Facilitator

Objectives

- Develop Partnerships between WPS and WPI
- Implement Technology/Engineering Portion of the Massachusetts Science and Technology/Engineering Curriculum Frameworks (MSTECF) by
  - Preparing Teachers
  - Developing K-6 Curricular Materials

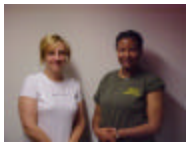
Lessons

- Lessons Address
  - MSTECF
  - Design Process
  - WPS Goals/Benchmarks
- WWW Dissemination via
  - Virtual Educational Space (Mass. DOE)
  - WPS Online Database
  - NSF Digital Library



2003-2004 WPS-WPI Team

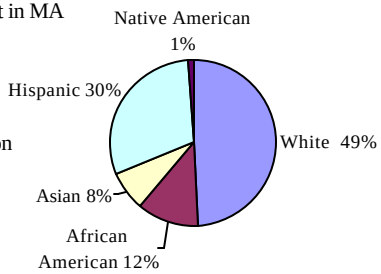
- 3 Grade Groups (4th, 5th, 6th Grades)
- 2 Classes/Grade
- Each group consists of
  - 1 Faculty Advisor
  - 2 Teachers (1/School)
  - 2 Graduate Fellows
  - 4 Undergraduate Students (2/Class)



"Scientists study the World as it is. Engineers CREATE the World that never has been."
- Theodore von Karman -

Worcester Public Schools Overview

- Urban
- 26,000 Students; 2nd Largest in MA
- Assets
  - Involved Parents
  - Dedicated Staff
  - Committed Administration
- Constraints
  - 83 Languages at Home
  - 50% Low Income
  - Declining Funding



Elm Park Community School

- 409 Students, Preschool-6
- Culturally, Ethnically Diverse
- Asset: Strong Literacy and Math Programs
- Constraint: High Student Mobility due to Unavailable Student Housing

Midland Street School

- 230 Students, K-6
- Culturally, Ethnically Diverse
- Asset: Strong Math and Science Programs
- Constraint: Space

3 Year Project Schedule

- 2003-2004
  - Two Schools, 4th, 5th and 6th Grades
- 2004-2005
  - Add 2nd and 3rd Grades and Schools
- 2005-2006
  - Add K and 1st Grades and Schools
- Staffing Model:
  - Grad Fellows Provide Initial Support
  - Teacher Mentors and Undergraduates Support Successive Years

2003-2004 Yearly Activities

- Summer – Teachers and Fellows
  - One Week June Workshop
  - 3 WPI Outreach Programs
- Fall and Spring – Teachers, Fellows and Undergraduates
  - WPI Students Visit Classrooms 2-3 X/Week
  - WPS Students Visit WPI
  - Regular Teacher, Principal Meetings
  - Weekly Team, Grade Meetings
- School Committee Presentation
- PTO Meeting Presentations

Assessment

- Recruitment of WPS Teachers
- Student Learning Outcomes
- Teacher Preparation

Dissemination

- ASEE New England Regional Conference, April 04
- ASEE National Meeting, June 04

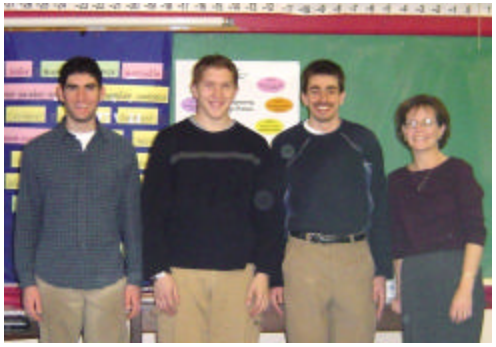
"Aw, Do We Have to Stop?"

WPI: Rick Bara, Graduate Fellow; Dan Abramovich, Jason Ernst, Undergraduates
WPS: Susan Bercume, 4th Grade Teacher; Patricia McCullough, Principal

Group Philosophy

- Everyone can think like scientists and engineers
- Using everyday objects, so learning continues at home
- Children learn better when they're having fun
- The toughest part is telling them **class is finished!**

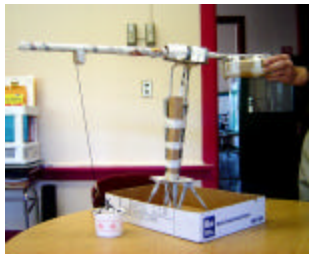
Midland St. 4th Grade Team



Therefore O students study mathematics and do not build without foundations.
- Leonardo Da Vinci

Rick's Lessons

- Intro. to Science & Engineering – more than chemistry labs & driving trains
- Cran-ee-um – test & re-design of construction cranes



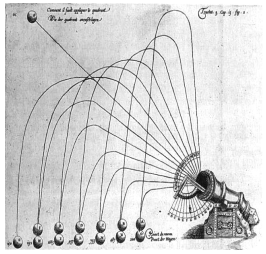
- Blast Off – scientific method & data collection with water rockets
- Weather or Not – rain gauges & the decision matrix
- Sound Off – pitch, loudness & design of musical instruments
- Wire Your House – selecting appliances without blowing a fuse

Additional 4th Grade Activity

WPI Robotics Demonstration

Jason's Projectile Motion Unit

- "Out to Launch"
- Tools & springs
- Potential & kinetic energy
- Design & test of hypothesis



- Launching projectiles
- Recording & interpreting data

Dan's Bicycle Physics Unit

- Bikes use many simple machines
- Applying math & science to design
- Frame geometry
- Gear ratios, cadence & speed
- Friction & brakes
- Levers & handlebars

Science and Engineering Notebooks
Elm Park 4th Grade

Worcester Polytechnic Institute: Graduate Fellow Amanda Tucker; Undergraduates Michael Schenck and Ermelinda Shahu
Elm Park Community School (EPCS): Principal Ruthann R. Melancon; Teacher Michael Dunphy

Notebook Examples

Scientist/Engineer Definitions

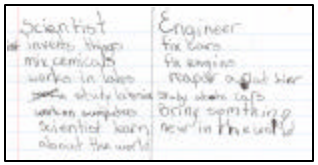
Students were asked to write down their ideas about what scientists and engineers do for jobs.

Most thought that scientists mixed chemicals and engineers repaired cars or drove trains.

Final definitions given to students

Scientists learns about the world.

Engineers bring something new into the world.



Water Rockets

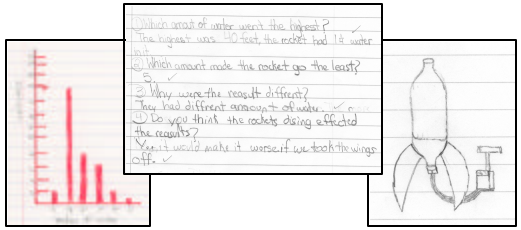
As an introduction to engineering, the topic of rocket propulsion was explored.

As a class we discussed how a water rocket works.

In groups, students decided how much water they would use to launch a water rocket.

The groups' hypotheses were tested.

The results of the tests were graphed and discussed.



Use of Notebooks in Classroom

- Notebooks passed out at start of lesson
- Lesson topic and date are recorded
- Students sketch and take notes during lesson
- Students complete a lab write-up or answer questions after lesson
- Students respond to teacher's written comments concerning past lessons
- Teacher makes comments/corrections in books

Objectives

- Unify science and engineering experiences
- Develop interest and pride in science and engineering work
- Develop a year long record of activities
- Allow personal dialog between graduate fellow and grade school students

Challenges with using Notebooks

- Students' limited writing skills
- High mobility
  - A year of work is not complied
  - New students need new books
  - Returning students start over

Assessment

- Notebooks are reviewed after lessons
- Corrections and comments are made
- Respond to written student questions
- Watch for student improvement

Notebook Examples

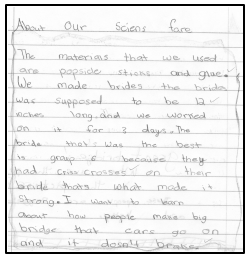
Model Bridges

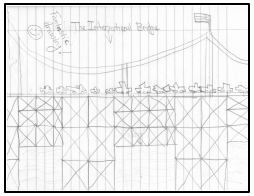
As an introduction to civil engineering the students took part in a bridge building exercise.

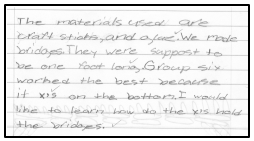
Students designed a bridge on paper and than built it out of craft sticks and glue.

The bridges were tested to find out the maximum load they could hold.

Student discussed and wrote about the results of the tests.



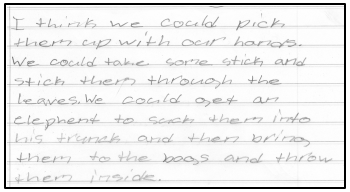




Brainstorming

Brainstorming activities have helped encourage the students to think creatively as engineers.

We asked students to think of ways to get leaves out of the school yard without using rakes.



The Engineering Design Process in the 5th Grade Classroom

Worcester Polytechnic Institute: Colby Hobart, Michael O'Donnell, Josh Pesch
Midland Street School: Patricia McCullough, Principal; Michele Sullivan, Teacher

Step 1: Identify the Need or Problem

•Students shown erosion demonstration
•Asked how to prevent erosion
•Students decide on building a fence that will allow water to pass, but will hold soil back.

Step 2: Research the Need or Problem

•Research for this project is done in the form of a lecture by the teacher.
•Students take notes and learn about the erosion process.

Step 3: Develop Possible Solutions

•Students grouped in three or four members.
•Within the groups they brainstorm their ideas for a fence.
•At this point, all ideas are recorded.

Step 4: Select the Best Possible Solutions

•Each group decides on their best solution.
•Students then create a final design including the dimensions
•Students submit a list of materials to their teacher.

Step 5: Construct a Prototype

•Groups build their first prototype.
•The fences are made from craft sticks, straws, pipe cleaners, wire, and glue.
•The students are given two class periods for building.

Step 6: Test and Evaluate the Solution

•The students set up their fences within the soil containers
•Each group channels four liters of water into the containers
•Students evaluate the performance of their detainment fences.

Step 7: Communicate the Solution

•The students put on a demonstration for the kindergarten class at Midland Street School
•Students explain:
  •How they arrived at the solution
  •How their specific fences were designed and built.

Step 8: Redesign

•Groups redesign and rebuild their fences to accommodate any shortcomings of the original prototypes.

Erosion Engineering

Purpose: To teach the 5th grade students at Midland Street School how the erosion process works, while placing a strong emphasis on the engineering design process.

Redesigning the Engineering Design Process for 5th Grade

Worcester Polytechnic Institute: Jonathan Scobo, Elijah Mojica, Elizabeth Tyree
Worcester Public Schools (WPS): Lisa Ansara, Teacher (Elm Park School)

Step 6: Redesign

Dream house economics: Given a list of cost items, figure the cost of your dream house. If the total for the house exceeds savings, redesign.

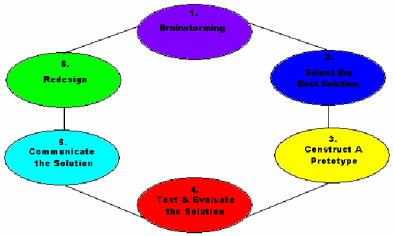
Step 5: Communicate the Solution

Scale: Find your own house on a map, measure the distance from their house to their school, and convert actual distance to scaled distance.

Step 1: Brainstorm

Money recovery: Get a $100 bill out of a simulated storm drain without entering the sewer system.

Purpose: To create a simplified Engineering Design Process suitable for the 5th Grade



Step 4: Test and Evaluate the Solution

Magnetic levitation: Make a car that will levitate on a magnetic track and will travel down the full length of the track.

Step 2: Choose Best Solution and Sketch it

Dream house floor plan: Given a list of interior and exterior dimensions, choose and sketch a design for your dream house (with amenities such as pool and basketball court).

Step 3: Construct a Prototype

X-Planes: Make a paper airplane that performs certain maneuvers.

Engineering and the Human Body

Midland Street School, 6th Grade

WPI: Sarah Linderme, Graduate Fellow; Crystal Bishop and Kevin Fichter, Undergraduates
WPS: Cecilia Gray, Teacher; Patricia McCullough, Principal

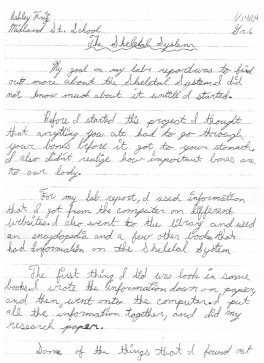
Objectives

- Teach the 5 Major Systems of Human Body
- Introduce Biomedical Engineering
- Relate Biomedical Engineering to 5 Systems
- Develop Lab Report Writing Skills

Massachusetts Frameworks

- Life Sciences Strand 2
  - Systems In Living Things
    - ➢ Describe Organization of Multicellular Organisms
    - ➢ Present General Functions of Major Bodily Systems
- Technology/Engineering Strand 4
  - Explain Examples of Adaptive/Assistive Devices
  - Describe/Explain Adaptive And Assistive Bioengineered Products

Student Work



Ashley Fitz 1/14/04
Midland St. School 6th
The Skeletal System

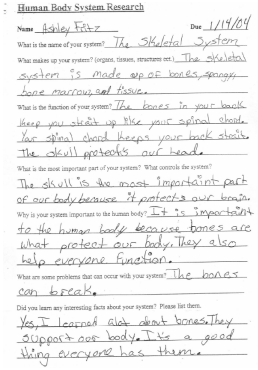
My goal in my lab reportsions to find out more about the skeletal system. I did not know much about it until I started.

Before I started this project I thought that anything you ate had to go through your bones before it got to your stomach. I also didn't realize how important bones are to our body.

For my lab report, I used information that I got from the computer on different websites. I also went to the library and used an encyclopedia and a few other books that had information on the skeletal system.

The first thing I did was look in some books & wrote the information down on paper, and then went onto the computer & put all the information together, and did my research paper.

Some of the things that I found out



Human Body System Research

Name Ashley Fitz Due 1/14/04

What is the name of your system? The Skeletal System

What makes up your system? (organs, tissues, structures ect.) The skeletal system is made up of bones, spongy, bone marrow, and tissue.

What is the function of your system? The bones in your back keeps you straight up like your spinal chord. Our spinal chord keeps your back straight. The skull protects our head.

What is the most important part of your system? What controls the system?
The skull is the most important part of our body because it protects our brain.

Why is your system important to the human body? It is important to the human body because bones are what protect our body. They also help everyone function.

What are some problems that can occur with your system? The bones can break.

Did you learn any interesting facts about your system? Please list them.
Yes, I learned alot about bones. They support our body. It's a good thing everyone has them.

Activity #1: *Instruction*

- Major Functions of Human Body
- Windows on Science
- Lecture:
  - Tissues
  - Organs
  - General Systems

Activity #2: *Group Research*

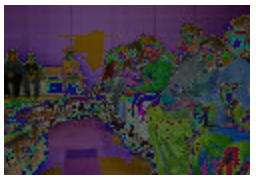
- Small Research Group
  - 3-4 Students per Group
  - Use Computers and Encyclopedias to Research 5 Systems
- Lab Report

Activity #3: *Biomedical Engineering*

- Lecture on Biomedical Engineering
  - Product Examples:
    - ➢ Artificial Organs
    - ➢ Contact Lenses
  - Traditional and Non-traditional Job Opportunities
- Relate Biomedical Engineering to Body Systems
  - Virtual Tour of Human Body on a TV
  - Relate Virtual Tour to Bioengineered Products

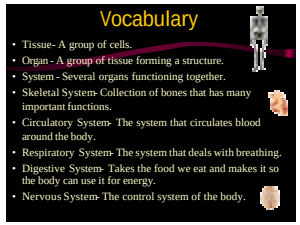
Classroom

- 15 Boys, 18 Girls
- Ethnically Diverse Group of Students
- Socioeconomically Diverse
- A Variety of Academic Needs
- 12 Peak (Advanced Students)



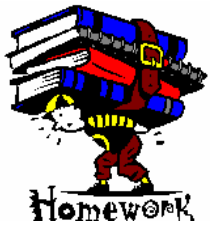
Supplements

- Vocabulary Lists
- Lesson Bulletin Board
- Worksheets
- Interactive Website



Assessment

- Student Learning Outcomes
- Rubric
- Homework
- Lab Write-Up



Observations

- Successes
- Challenges
- Modifications

Airplane Design

Elm Park Community School, 6th Grade

WPI: Brian Lehtinen, Graduate Fellow; Julie Bradley and Meagan Ward, Undergraduates
WPS: Jodi Watson, Teacher; Ruthann R. Melancon, Principal

Objectives

- Propulsion and Natural Forces
- Transportation
- Airplanes

Massachusetts Frameworks

- Engineering/Technology, Strand 4
  - Identify and Describe Subsystems of Transportation.
  - Identify and Explain Lift, Drag, Friction, Thrust and Gravity.

Classroom

- 21 People in Class
- MCAS Rank is 1017th/1037
- 5 New Students, 2 Left
- 70% Speak Another Language More Fluently than English

Activity #1: *Brainstorm*

- Forces
- Correct Misconceptions

Activity #2: *Research*

- Explain with Pictures and Diagrams
  - o Airplanes
  - o Propulsion

Activity #3: *Prototype and Test*

- Prototype Airplane
- Test Flying Distance.

Activity #4: *Prototype Redesign and Test*

- Redesign One Aspect of Airplane.
- Test Flying Distance.

Activity #5: *Communicating the Solution*

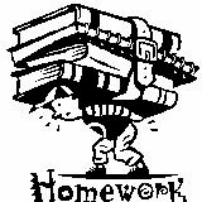
- Discussion on Airplanes and Forces
- Presentation
- Lab Report and Homework

Supplements

- Bulletin Board
- Vocabulary/ Spelling List
- Lab Report
- Handouts
- Discussion Questions

Assessment

- Rubric
- Homework
- Lab Report
- Student Learning Outcomes



Observations

- Successes
- Challenges
- Modifications

Tool of the Month
Elm Park Elementary, 6th Grade

WPI: Brian J. Lehtinen, Graduate Fellow
WPS: Jodi Watson, Teacher; Ruthann R. Melancon, Principal

Objectives

- Learn how to use specific tools.
- Learn what tools are for given tasks.
- Learn to use the tools safely.

Massachusetts Frameworks

- Identify and explain appropriate measuring tools, hand tools, and power tools used to hold, lift, carry, fasten, and separate.
- Explain the safe and proper use of a tool.
- Identify the proper tool needed to construct a prototype of an engineering design.

Example

- December – Tools That Lift
  Levers, Gears, Block and Tackle, and Hydraulics

Activities:

- o Students Research on HowStuffWorks.com, finding Information and Pictures.
- o Pictures and Information on Tools That Lift are posted on Bulletin Board.
- o Ask questions on each tool throughout the month
- o Quiz at the end of month.

Schedule

- *First of the Month.* Find as much information as possible on the 'Tool of the Month.'
- *Throughout the Month.* Review information and ask questions on the information found.
- *Last day of the Month.* Assess students to determine how much information they retained about the Tool.

Lessons

- Learn about the Tools
  - o Internet Research
  - o Read articles
  - o Brainstorm uses
  - o Display Information Bulletin Board
- Review Tools
  - o Ask questions on what was learned
  - o Homework – Crossword puzzles, word searches
- Assess Student Learning
  - o On information about the tools
  - o On applying understanding

Tool Examples

- September – Drill Press
- October – Band Saw
- November – Tools That Hold
  - o C-Clamp
  - o Band Clamp
  - o Spring Clamp
  - o Vise

Website Resources

- Band Saw & Drill Press.
  http://teched.vt.edu/ElectronicPortfolios/Schnitz.ep/MachineSafety/Safety.html
- Clamps.
- http://www.adjustableclamps.com
- How a Block and Tackle Works.
  www.howstuffworks.com/pulley.htm

Assessment

- Quiz on the last day of month
- Tools of the Month included on Engineering mid term and final

Student Outcomes

- Some students that would usually have trouble with tests do well on the tool quizzes.
- Both genders enjoy learning about new tools and their uses.

Developing an Online Lesson Plan Repository

Worcester Polytechnic Institute: Jared Devlin-Scherer, Neel Pendse, Marek Twarog
Worcester Public Schools: Kathy Peloquin

Objectives

- Online database for lesson plans
- Standardized form for adding/viewing lesson plans

What is the Relevance?

- Teachers can access older lesson plans for curriculum use
- Users can view success of lesson plans to plan future lessons
- Database will be owned specifically by the school

Purpose

- Need for organized storage facility of lesson plans that is accessible to teachers
- Allows for a possibility of having one storage utility state or nation-wide
- Owned by the Worcester Public Schools

What can Teachers do?

- Type lesson plans in word documents
- Upload the lesson plans via cut/paste
- View uploaded lesson plans of others
- Rate lesson plans and view ratings
- Modify lesson plans and share them

The Power of Online Databases

- Access to all uploaded lesson plans
- Ability to modify and create lesson plans for users
- Rating system for efficiency of lesson plans

The Inner Workings

- Retrieving data from database similar to web searches
- Teachers can use database functions to search and filter through files.

How does it work?

- MySQL Details
  - free open source programming language
  - database management tool
  - compatible with any database system
  - allows users powerful search engine

Online Form

- User-friendly form to upload/download plans
- Similar to buying anything from the internet
- Form communicates to database server
- Teachers may query lesson plans

Online Database

- Server stores lesson plans/additional information
- Database is designed with MySQL language
- Database will be accessible by the technology team of the Worcester Public Schools

K-12 Robotics Outreach

Inspiring young scientists and engineers

WPI First team, "Gompei and the HERD"
Advisor: Ken Stafford; Chief of Tactics: Colleen Shaver.

"FIRST is about the right stuff; a better way of learning; informed, creative thinking. It's about gracious professionalism making your brain hurt, and yes, having fun"
Woodie Flowers, Ph.D., FIRST national advisor

Why Robotics?

- Provides a fun vehicle for teaching mechanical, computer, electrical engineering principles.
- Myriad of opportunities for practical applications of math, physics, and computer science.

What is FIRST?

- FIRST mission: to design accessible, innovative programs to build self-confidence, knowledge and life skills while motivating young people to pursue opportunities in science, technology and engineering.
- Nonprofit organization founded by Dean Kamen now has over 920 high school teams and over 2200 4th through 8th grade teams participating--more than 50,000 students total.

WPI Involvement

- Member of FIRST Executive Board
- Has sponsored a FIRST team since program began in 1992
- Most popular student activity on campus (220 student mentors).
- Year-round outreach program.

K

K-3: Community Outreach

- WPI students provide robotic demonstrations to schools, organizations, churches, clubs, libraries, etc. throughout the commonwealth.
- Children learn about robotics and engineering—then see and operate the competition robots.
- Typical year includes 40-50 demos with total audiences exceeding 20,000.

3

4-8: FIRST LEGO League

- Students design, build, and operate robots constructed from a FIRST version of LEGO's Mindstorms Robotic kit.
- WPI student mentors aid teams in robot design, programming, and research.
- Competitions require timed autonomous robot operations and multiple presentations to judges.
- WPI hosts ***RoboNautica***, a 40 team Massachusetts State FLL Championship.

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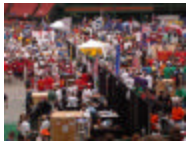

9-12: Robotics Program

- ***Frontiers:*** a 2 week intensive summer program designed to teach students the basic principles of robot design and construction.
- ***Savage Soccer:*** a 3 week fall program for local high schools to design, build, and compete with EDUrobots.
- ***FIRST Robotics Competition:*** a 6 week winter build, then a month of regional/championship tournaments.
- ***BattleCry@WPI:*** a premier WPI-sponsored spring tournament for FIRST teams from 40+ high schools.
- ***Team 190:*** the WPI-sponsored FIRST team comprised of students from the Mass Academy of Math and Science and other Worcester-area schools.