AC 2007-2021: ENGINEERING APPLICATIONS FOR MIDDLE SCHOOL MATHEMATICS EDUCATION:

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Engineering Applications for Middle School Mathematics Education: Supporting an Inquiry-Based Classroom Environment

Abstract - Engineering faculty at the University of Alabama at Birmingham are participating in a middle school mathematics partnership, involving nine school districts (administrators, teachers, parents) and higher education faculty at two universities, and the Mathematics Education Collaborative (MEC). The partnership promotes inquiry-based learning curricula modeled after the National Council of Teachers of Mathematics, Principles and Standards for School Mathematics. The engineering faculty contribution to the partnership lies in the connection of mathematics to real world applications and to users of mathematics within the framework of an inquiry-based middle school mathematics classroom. The engineering faculty have surveyed many existing science and engineering based problems and activities, both to determine what is available and how our local teachers might use them. A number of resources exist that provide real world examples applicable to middle school mathematics. In some cases these activities are presented in a format that is difficult for teachers to adapt to an inquiry-based pedagogy in a mathematics classroom. Resources are also available that provide application-oriented problems in the form of word problems. These resources provide students with a connection to real world applications in their everyday lives and are supportive of inquiry-based practices. However, our local teachers wanted students to become more engaged in the problems by discovering how the mathematics is used to help solve critical problems in applications of interest. Engineering research and development relies on mathematics and covers many areas of interest for middle school students. Although many wonderful resources are available that provide educators with a connection between engineering, science, mathematics, and real world applications, there is a need for development in support of inquiry-based engineering application tasks for the middle school mathematics classroom. In this paper, available resources for engineering applications in middle school classrooms, inquiry-based pedagogy, and the need for engineering applications supporting inquiry-based mathematics education are presented. Development of the first new application task in this effort and feedback from middle school mathematics teachers are also briefly discussed.

Keywords: K-12, Mathematics, Engineering Applications

Introduction

Engineering faculty at the University of Alabama at Birmingham are participating in the Greater Birmingham Mathematics Partnership (GBMP), a middle school mathematics partnership, involving: nine school districts (administrators, teachers, and parents), higher education faculty at two universities, and the Mathematics Education Collaborative (MEC). Grades 6-8 in participating districts are made up of approximately 21,840 students and 274 mathematics teachers. The partnership promotes inquiry-based learning curricula modeled after the National Council of Teachers of Mathematics, Principles and Standards for School Mathematics through content and pedagogical preparation of future teachers, the professional development of practicing teachers, and the placement of interns in classrooms that model exemplary practices [1].

The engineering faculty contribution to the partnership lies in the connection of mathematics to real world applications and to users of mathematics within this framework of an inquiry-based middle school mathematics classroom. In developing these connections, the engineering faculty hope to provide middle school mathematics teachers with the experiences and the confidence to answer their students when they ask, "How will I ever use this?" In answering this question, what could be more effective than demonstrating applications of mathematics and who uses mathematics? These activities directly support the May 2005 NSF Engineering Task Force recommendation to, "support and expand pre-college teachers' understanding of the engineering profession, especially the creative, innovative aspects…" [2].

The field of engineering is well suited to demonstrate the usefulness of mathematics, since it applies the principles of science and mathematics to create solutions to practical problems for the benefit of mankind. Engineering research and development includes many applications of interest to middle school students. Although many wonderful resources are available that provide educators with a connection between engineering, science, mathematics, and real world applications, there is a need for development in support of inquiry-based engineering application tasks for the middle school mathematics classroom, as illustrated in Figure 1.

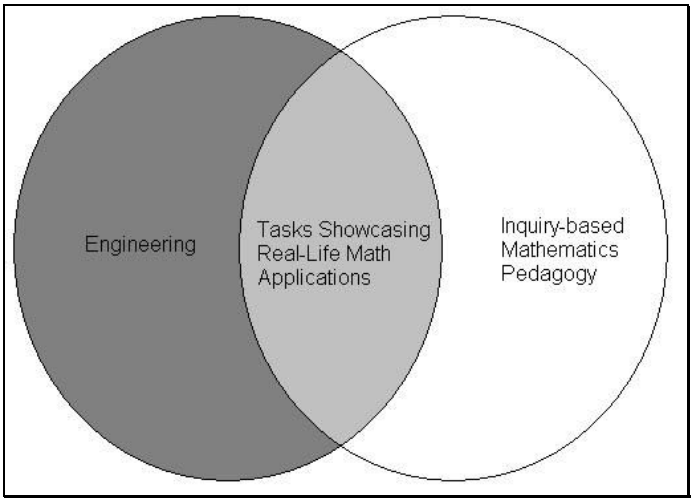

Figure 1. Integration of Project Goals

At the same time, narrow views of what constitutes engineering have resulted in increasingly reduced pools of students interested in pursuing engineering as a career, a decrease of approximately 2,000 students from 1991 to 2002 [2,3]. This is especially true among groups, including women and minorities, who have traditionally been under-represented in the engineering work force. The number of women interested in pursuing engineering as a career decreased from approximately 11,000 to 9,000 from 1991 to 2002 [2,3]. The number of minorities interested in pursuing engineering careers has also been decreasing after peaking in 1995 [2,3]. A connection between mathematics and engaging engineering applications in the middle school classroom offers an opportunity to foster not only a better understanding of mathematics content, but also interest in pursuing engineering careers.

Partnership Background [1]

Working with colleagues at the NSF sponsored Math and Science Partnership conference on challenging courses and curricula and the five strands of teaching for math proficiency (from the National Research Council report, *Adding It Up* [4]), GBMP has arrived at a definition of challenging courses and curricula. For GBMP, there are four key aspects of challenging courses and curricula:

- Deepening Knowledge of Important Mathematical Ideas
- Productive Disposition
- Inquiry and Reflection
- Communication

Deepening knowledge of important mathematical ideas includes developing conceptual understanding, procedural fluency, and strategic competence. A productive disposition includes developing a willingness to persist in working on mathematical problems and developing confidence in one's own ability to solve mathematical problems. Inquiry and reflection includes use of inquiry-based activities and reflecting on learning experiences individually, in groups, or as a class. Communication includes the ability to articulate one's mathematical ideas verbally and in writing to peers, teachers, parents, and others.

GBMP's professional development curriculum for teachers involves a sequence of seven intensive mathematics content courses taught or co-taught by MEC staff each summer. The mathematics content consists of the "big mathematical ideas" of numerical reasoning, algebra, geometry, probability, and data analysis as identified in NCTM's *Principles and Standards for School Mathematics* [5]. Each course models the attributes of challenging courses and curricula that are the heart of the GBMP, providing an environment that optimizes the learning of quality mathematics while meeting the needs of a broad range of learners. This therefore allows access for those teachers who fear and/or dislike mathematics, yet challenges all participants.

The MEC courses use a "menu"-based learning environment. "Menu" environments are used to surround students with a mathematical concept that they encounter in a variety of contexts and to explore a variety of mathematical strategies and tools. In the "menu" learning environment, students have a number of tasks, or investigations, to complete by a given date. Tasks are usually posted around the classroom and students make choices about working alone or in groups and which task they want to work on. Student work is self-directed and students are responsible for recording their own work in a menu book. [6]

The nine school districts, in partnership with MEC instructors and co-project directors, have chosen teacher leaders, called Mathematics Support Team teachers (MST's). GBMP offers leadership development and extended support to the MST's. To build leadership skills, GBMP engages these MST's in a series of special seminars that extend their understanding of mathematics, enhance their personal mathematical dispositions, expand their abilities to teach mathematics, and build both the willingness and the skills necessary to take on leadership roles within their school systems. The MST's lead in the implementation of the partnership's definition of challenging courses and curricula. In addition to leadership support in their

respective school systems, MST's implement informal mathematics study sessions for classroom teachers in their schools.

Survey of Existing Materials

A number of resources exist that provide real world examples applicable to middle school mathematics, including those made available by: TeachEngineering, NASA, AMSTI, and PBS. These resources have been catalogued and reviewed for types of information, relation to desired pedagogy, types of activities (word problems, applications and experiments), and classroom commitment for mathematics teachers. A summary is provided in the Appendix. There are many science and or engineering activities that provide engaging applications of the math concepts. Most of these activities, however, require a significant amount of class time to perform experiments and to explain the scientific and engineering principles involved. The scope of this partnership is focused on mathematics preparation and there is no prescribed involvement from middle school science educators; therefore the exercises are limited to the mathematics classroom. The math teachers often do not have the confidence, experiences, or time necessary to connect the science and engineering principles to the mathematics concepts. Many of these activities are also presented in a format that is difficult for teachers to adapt to an inquiry-based pedagogy in a mathematics classroom. There are also resources that provide tasks and activities to reinforce critical math concepts. These can be engaging and similar to the tasks used in the MEC menus, but are not application driven. Several other resources provide application-oriented problems in the form of word problems or interactive games such as Connected Math, the Real-Life Math series, and various websites. These resources can provide activities that give students a connection to real world applications in their everyday lives as well as can be supportive of inquiry-based practices. In most cases, however, the activities tend not to meet the needs of a broad range of learners; allowing access for those who fear and/or dislike mathematics yet challenges all participants.

Initial Development of Engineering-based Application Tasks

There was therefore deemed a need to develop application oriented activities teachers could use in a challenging course. Initial constraints for the development of new application tasks were developed through research, field testing, and discussion among the partnership's design team. As part of this, each member of the Engineering Projects team participated in the MEC *Patterns, Functions, and Algebraic Thinking* course during Summer 2005 with in-service teachers to understand the pedagogy of challenging courses and curricula as defined by the partnership.

The consensus was that application tasks in the field of engineering could be used to engage students in problems by discovering how the mathematics is used to help solve critical problems in applications of interest; since engineering is the application of science and mathematics to create solutions to practical problems for the benefit of mankind. Specifically, the application of science and math can be used to 1) design components, devices, or processes to give a desired outcome, 2) optimize (improve efficiency, speed, effectiveness, etc.) a design or process, 3) control a process or system to achieve a desired outcome by quantifying the various steps of a real or modeled process, and 4) develop or optimize quantification techniques. In each of these 4 overlapping areas the solution is limited by a variety of constraints (i.e. time, cost, and current

technology). The tasks developed should incorporate these classes of engineering problems with engaging applications supporting the "big mathematical ideas" of numerical reasoning, algebra, geometry, probability, and data analysis [5].

It was therefore important to determine what would be engaging to middle school students and useful to middle school teachers. In the summer of 2005, approximately 150 teachers participating in the MEC summer courses were asked to respond to the following questions:

1. What excites kids in middle school?
2. How would you like to use math applications in the classroom?

Teachers responded in terms of concepts, activities, and applications. In response to question 1, teachers listed concepts like: motor vehicle design, skateboarding, anything gross, fashion, sports performance (equipment and technique), genetics, artificial skin, recycled materials, storm proofing, military combat systems, roller coasters, music, environmental issues, how things work, technology, and biology. Teachers listed activities like: field trips; model rockets; outdoor activities; hands on manipulation, construction, and experiments; speakers in the classroom; simple computer aided design and animation. In response to question 2, teachers listed concepts like: hypothesis testing, cooperative learning, problem solving, small group or individual projects related to student interests, math-science connections and careers, and hands on experiences extended with computer activities. Teachers also included activities like: collecting data, measuring, graphing, designing, and building. Teachers were also interested in using manipulatives with the applications, a mapping of grade-level standards from the Alabama Course of Study [7], and opportunities to build a student-selected menu of tasks.

Also as part of this, it was revealed that they already had access to the traditional types of "building" projects commonly associated with engineering applications (ramps and levers). It was felt, however, that these types of projects were better incorporated in science classes and/or required a significant amount of class time when compared to the mathematical benefit derived.

Defining Constraints

Based on this input from local teachers, different strategies were proposed and discussed in meetings with others involved in the GBMP including other faculty, District Liaisons, Mathematics Support Team teachers, and the Design Team to crystallize the focus of the engineering projects. Ultimately, it was determined that the engineering tasks should be designed within the following constraints:

- Tasks should link directly to a MEC course (Patterns, Functions, and Algebraic Reasoning; Geometry and Proportional Reasoning; Probability and Data Analysis; and Numerical Reasoning)
- Tasks should follow the pedagogy associated with the MEC courses
    - Challenge the "productive disposition" of the students; pushing them to seek multiple mathematical approaches and strategies for deeper mathematical understanding.

    - Meet the needs of a broad range of learners; allowing access for all, yet challenging all participants--allowing opportunities to explore and extend their strategies and solutions.
- Tasks should link directly to the Alabama Course of Study [7]
- Tasks should fit into the classroom menu format
- Tasks should highlight some aspect of current engineering research or practice
- Tasks should be self contained
- Tasks should be factually and conceptually correct (in an effort to avoid initiating or perpetuating misconceptions or oversimplifications of scientific concepts)

Task 1: Wound Healing for Patterns, Functions, and Algebraic Thinking

The first task developed and presented, "Wound Healing", was carefully crafted to be paired with the MEC *Patterns, Functions, and Algebraic Reasoning* course, and to fall within the constraints listed above. The application of science and math can take many forms, including innovative solutions to enhance wound healing, the topic of the first engineering task presented. This topic comes from the discipline of Biomedical Engineering, which is defined as the application of engineering principles and technology to the solution of problems in the life sciences and medicine. A biomedical engineer involved in wound healing research can 1) design devices to facilitate healing, 2) determine ways (including devices) to optimize the speed and completeness of healing, 3) model the healing process in order to understand the best ways to control the process, and 4) develop or optimize techniques to better assess the healing process.

This task relates to 3 and 4, which are being used to help design treatments and devices to optimize the healing process (e.g. an electrical stimulation bandage is currently being tested clinically). A critical part of understanding the healing process is that it can be modeled as a linear healing rate. Currently many physicians and the FDA do not fully understand this. This is important so that healing in any time interval can be compared to other time intervals and to different wounds to assess the health of a wound, the effectiveness of treatment, the need for corrective measures, or in the case of this task: how long it will take to heal. Engineers track the rate of healing by measuring the wound at regular intervals. They evaluate the progress of several patients and several treatment methods and compare the results to evaluate exciting new treatment options. The results of their work are shared with doctors and hospitals to improve wound care across the world [8].

The "Wound Healing" application demonstrates how a linear function and geometry concepts are used by engineers to quantify the healing process in order to support this research and better control the healing process. The task demonstrates one application for students to see how these mathematical concepts are used and by whom. The "Wound Healing" task is provided in the Appendix as well as the related teacher notes. Extensions for this task have been developed to help teachers further explore linear and non-linear functions as well as geometry concepts with their students. These extensions are also provided in the Appendix.

Evaluation of Wound Healing Task

When complete, the task was presented to a group of MSTs for evaluation and preliminary field testing. Initial comments were overwhelmingly positive. Three middle school MSTs piloted the task with their students and provided both feedback and samples of student work. All of the participants reported that the task really did live up to their purpose of answering for the students the question, "When are we ever going to use this [math] stuff?" One participant even believed that the Wound Healing Task actually answered that question for the entire menu presented in the first course. Other teacher comments with respect to how well the Wound Healing Task helped their students see the value of math in their lives included:

"The students loved it. It really allowed the students to connect patterns and functions to real life."

"…giving students this opportunity to see how math works in society made them feel like their work is worthwhile."

"[Students] told me they would calculate their own healing rate the next time they had one."

"They could really see the value. They related it [the task] to future jobs they may have."

This served as a resounding endorsement of the engineering application task and the continued development of similar tasks.

In subsequent sessions, MSTs who did not use the Wound Healing Task were asked why they chose not to use the task with their students. Some teachers thought that the task was too "easy" for their students, but admitted that they had not explored alternate solutions or strategies. The teachers also requested extensions for the problem with in-depth explanations provided for the teachers. In response to this feedback, problem extensions, "desserts", were developed and additional teacher materials created. A website (http://homepage.mac.com/lmeadows/engineeringtasks.html) has been created to allow for continued dissemination of materials and for continued feedback from middle school teachers and students.

Continued Task Development and Web Support

Task 2 is currently under development and explores Metal Fatigue using Paper Clips for Probability and Data Analysis concepts. This activity has been piloted successfully in freshman "Introduction to Engineering" courses at UAB in Fall 2006 and adapted for middle school use. In the future, application oriented tasks will be developed to extend and integrate instruction on functions, algebra, geometry, probability, and statistics.

All tasks, teacher notes, and available resources resulting from this work are shared at: http://homepage.mac.com/lmeadows/engineeringtasks.html. The website allows for easy access to color pictures presented in the tasks. It also provides extensions of engineering tasks, including: more difficult problems, related problems, the science behind the problems, and the math behind the problems. The website offers a mapping of MEC course content to the Alabama Course of Study. Most importantly, the website allows the engineering team to receive feedback from teachers and students and to respond to questions posed by teachers and students.

Conclusions

A review of existing materials in support of mathematics education has shown a need for engaging application oriented activities supporting inquiry-based pedagogy in middle school mathematics classrooms. In response to this, Engineering faculty developed a Wound Healing task to explore functional relationships and geometric concepts to be used within the constraints of a challenging course and curricula established by the GBMP. The task was piloted successfully by middle school mathematics teachers in their classrooms. Teachers, however, have also provided valuable suggestions to improve the task, which are currently underway through the development of a user-friendly website. The development of this task has been a step in the right direction toward engaging students in mathematics used to help solve critical problems in applications of interest. Additional tasks are currently under development.

For additional information on the Greater Birmingham Mathematics Partnership, please visit: http://www.math.uab.edu/GBMP/.

For additional information on the Mathematics Education Collaborative (MEC), please visit: http://mec-math.org/.

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Appendix

Materials Reviewed
Task 1: Wound Healing (Task, Teachers Notes, and Extensions)

Materials Reviewed

Table A.1 Word Problems with Everyday Topics

Title	Source	Description
PRISM	http://www.rose-prism.org/moodle/	Digital materials catalogued to Indiana course of study, Interactive word problems.
Math Playground	http://www.mathplayground.com/index.html	Interactive word problems.
Math Goodies	http://www.mathgoodies.com/cd/	Interactive projects, not application oriented.

Table A.2 Related to Pedagogy, but not Application Oriented

Title	Source	Description
Text	Marilyn Burns, About Teaching Mathematics	Good for mathematics concepts, not application oriented
National Council of Teachers of Mathematics, Principles and Standards for School Mathematics	http://www.nctm.org/standards/	Good for mathematics concepts, not application oriented
MEC	http://www.mec.com/	Mathematics Education Collaborative

Table A.3 Science Related Kits and Experiments

Title	Source	Description
AMSTI	http://www.amsti.org/index.html	Science kits with teacher guides
NASA	http://spaceplace.jpl.nasa.gov/en/kids/ http://www.nsip.net/download.cfm	Good science based activities
PBS	http://www.pbs.org/teachersource/math.htm	Activities related to NCTM Standards

Table A.4 Application Oriented

Title	Source	Description
Math Application Projects	http://www.angelfire.com/ny/brockport/proj.html#box	Good Applications, long term projects (weeks)
Connected Math	http://connectedmath.msu.edu/	Good activities, not a complete match for pedagogy

Table A.5 Engineering Applications

Title	Source	Description
Teach Engineering	http://www.teachengineering.com/ from NSF GK12 program	Good engineering examples, time consuming for math classes, good resource
Discover Engineering	http://www.discoverengineering.org/default.asp	Games and knowledge
ASEE	http://www.engineeringk12.org/educators/go_engineering/news.html	
Paper Clip Fatigue	http://www.weibull.com/AccelTestWeb/paper_clip_example.htm	Used for Probability and Data Analysis
ASME	http://www.asme.org/education/precollege/ideas/	

Table A.5 Engineering Applications (continued)

Title	Source	Description
Pearson Learning Group	http://plgcatalog.pearson.com/program_single.cfm?site_id=2&discipline_id=808&subarea_id=1021&program_id=190	10 engineering Units

Table A.6 Informational

Title	**Source**	**Description**
Delta Education	http://www.delta-education.com/mathgallery.aspx?menuID=51	Sources of math books—many obtained
Nature of Mathematics	http://www.project2061.org/publications/bsl/online/ch2/ch2.htm?txtRef=&txtURIOld=%2Ftools%2Fbenchol%2Fch2%2Fch2%2Ehtm	research and goals for grade levels

Table A.7 To Support Pedagogy of MEC

Title	**Source**	**Description**
Pascal's Pyramid	http://buckydome.com/math/Article2.htm	Concepts in MEC courses
Probability Virtual Lab	http://www.ds.unifi.it/VL/VL_EN/index.html	Simulation for probability

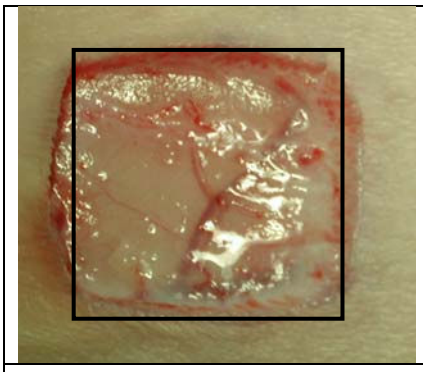
Other suggested sites

- Taking America's Measure (http://www.nist.gov/kids) A fun way to learn about measurements, science and technology for fourth to eighth grade students.
- The Internet Public Library Youth Division (http://www.ipl.org/youth/HomePage.html) Really neat math games and science experiments. Check out "So You Want to Make a Car" to play a create-your-own-company game!
- Yahooligans Directory (http://www.yahooligans.com/School_Bell/Math/Games_and_Puzzles) Elementary, middle, and high school math, games, and puzzles.
- QuizStar (http://www.aquiz.com/) Quizzes in many subjects from middle school up into college.
- WebShed.Com – Math Games (http://www.webshed.com/center/scitech/math_games.htm) Challenging science and technology math games.
- Kids Math (http://www.kidsmath.com/) Math quizzes for ages 3-12. Music, English Reading, and SAT quizzes are coming soon.
- FunBrain.com (http://funbrain.com/) Numerous kinds of games grouped by age and category.
- Math Strategies (http://www.pixelgraphics.com/) Math Strategies was chosen by teachers to reinforce key concepts. A demo version is available on this website.
- All Mixed Up (http://www.allmixedup.com/) A collection of on-line games for kids of all ages.
- Stanley Park Chase (http://schoolcentral.com/willoughby5/default.htm) Multiplication answers are rewarded by pretty pictures and more math and grammar skills questions until you solve the mystery.
- Puzzlemaker (http://puzzlemaker.school.discovery.com/) This website enables you to create your own puzzles.
- General Math (http://www.sisweb.com/math/general) This website provides numerous tables and math tips as well as games.
- Math Puzzle of the Week (http://www.mathpuzzle.com/) A math site containing the "Puzzle of the Week" plus a listing of many other sites for math and puzzles.
- WebMath (http://www.webmath.com/) Math problems of many types ranging from everyday math to calculus.
- Ken's Puzzle of the Week (http://www.ecst.csuchico.edu/~kend/potw/current.html) A math puzzle of the week.
- Uncle Bob's Puzzles (http://doe.ncia.net/~bobmead/puzzles.htm) Fun puzzles in varying degrees of difficulty. Submit solutions by e-mail.
- The Prime Puzzles & Problems Connection (http://www.primepuzzles.net/) An anthology of problems and puzzles explicitly related to primes.
- Puzzles & Riddles (http://www.iwr.uni-heidelberg.de/~Michael.Winckler/PUZ_bas.html) Word and math puzzles and links to puzzles around the world.

- The Ultimate Puzzle Site (http://www.dse.nl/puzzle/index_us.html) Interesting mathematical and non-mathematical puzzles.
- Colorful Mathematics (http://www.math.ucalgary.ca/~laf/colorful/colorful.html) Educational software presenting advanced mathematical concepts to K-12 students in a game-oriented approach.
- Thinks.com (http://www.thinks.com/) A website with math and word games.
- A+ Math (http://www.aplusmath.com/) A math website with games, homework help and advanced problems.
- Kids Domain Downloads (http://www.kidsdomain.com/down/index.html) This site has numerous math and science programs for children of varying ages that can be downloaded to your PC or Mac.
- BU's Interactive WWW Games (http://scv.bu.edu/Games/games.html) One-person and multi-player games of strategy.
- Clever Games for Clever People (http://www.cs.uidaho.edu/~casey931/conway/games.html) This Clever Games for Clever People website has a number of games from Joh Conway's book, On Numbers and Games.
- Interactive Mathematics Miscellany and Puzzles (http://www.cut-the-knot.com/content.html) In this website, click on games and puzzles and also explore a number of other interesting areas.
- MasterWeb (http://imagiware.com/masterweb) A game of logic.
- K-12 Math Puzzles from the Math Forum (http://forum.swarthmore.edu/k12/k12puzzles) Look here for math and critical thinking puzzles.
- 21st Century Problem Solving (http://www.hawaii.edu/suremath/home.html) A modern approach to problem solving-including those difficult word problems. This site is for students, parents, teachers, and other professionals.
- The Counting Game (http://home.earthlink.net/~cmalumphy/countinggame.html) An easy counting game for young children.
- Curious and Useful Math (http://personal.cfw.com/~clayford/frame1.html) Links to websites with lots of math "tricks."
- The Internet Schoolhouse (http://www.onr.com/schoolhouse/Math.html) Resource materials as well as links to geometry, puzzle and problem solving and other related sites.
- Math Games (http://www.useekufind.com/learningquest/tmfun.htm) Math games and puzzles for grades three through college plus other links such as Math at the Movies.
- The Study Hall Math Page (http://www.americatakingaction.com/studyhall/math.htm) Many math sites; pages for parents, students, teachers, and business directors; a preshool site--and more.
- Puzzle Jumpstation (http://www.puzzles.ca/linklist.html) A link to all kinds of puzzles, including interactive, mechanical, and optical illusions.
- Mathematics (http://www.ccps.k12.fl.us/schools/mms/Math.html) Math games for students, parents, and teachers.
- The Burr Puzzles Site (http://www.research.ibm.com/BurrPuzzles) Explanation and examples of burr (3-D) puzzles with links to other sties.
- Brian's Puzzle Page (http://www.btcomputing.com/puzzle.htm) Free puzzles and more.
- Helping Your Child Learn Math (http://www.ed.gov/pubs/parents/Math) Math game links - Shop at "The Grocery Store"
- Mrs. Glosser's Math Goodies (http://www.mathgoodies.com/) A free, educational web site featuring interactive math lessons for students, teachers, and homeschooling families.
- The Stock Market Game (http://www.smg2000.org/) An electronic simulation of Wall Street trading, designed to help students and adults understand the stock market, the costs and benefits involved in decision-making, the sources and uses of capital and other related economic concepts.
- Algebra Online (http://www.algebra-online.com/) This website is a free service designed to allow students, parents, and educators to communicate. It includes free private tutoring, live chat, and a message board.
- The Grey Labyrinth (http://www.greylabyrinth.com/puzzles.htm) Unsolved puzzles and puzzles with solutions. Also links to other puzzle sites.
- Try Some Puzzles (http://www.math.tau.ac.il/~puzne/gif/brain.htm) Puzzles ranging from easy to advanced to tough.
- Sheppard Software (http://www.sheppardsoftware.com/) A site for math, trivia, and vocabulary contests.
- Swarthmore (http://www.forum.swarthmore.edu/students) Math challenges for ages 5 through high school.
- The Event Inventor (http://www.kyes-world.com/) Projects and explorations in math, science, and technology.
- GoMath.com (http://www.gomath.com/) GoMath's purpose is to try to create the most dynamic and useful math site on the Web.
- SOS Math (http://www.math.utep.edu/sosmath) Help for doing homework, preparing for a test and getting ready for class, plus links to additional sites on the web.
- Special Math Word Problems (http://www.stfx.ca/special/mathproblems/welcome.html) Word problems for kids Grades 5-12.
- Math on the Web (http://ouray.cudenver.edu/~lwlana/math_ed.html) A listing of a variety of math sites from homework help to math in art and music.
- Brain Teasers (http://www.eduplace.com/math/brain) Brain teasers for grades three and up.
- Links (http://www.esu11.k12.ne.us/esu/resources/Math.html) A list of links for math resources, games and fairs.
- Learner.org (http://www.learner.org/exhibits/dailymath) Learn exciting details of how math affects our daily life from home decorating and cooking to population growth or visiting a casino.

Application Task #1

Wound Healing

		
Today	1 week	2 weeks

Wound size

Using a ruler, measure the dimensions of the wound to the nearest millimeter at each stage and record.

Investigations

How long will it take for this wound to heal completely?

How long would it take for this wound to heal if it was measured today to be 18 mm $\times$ 18 mm?

How long would it take for this wound to heal if it was measured today to be 60 mm $\times$ 60 mm? How large would the wound be after 3 weeks of healing?

How long does it take for a square wound of any size to heal?

Teacher Notes

Application Task #1
Wound Healing

Description: This task can be used to explore linear and non-linear functions, area and perimeter relationships, and measurement of congruent figures.

Supplies needed: Rulers with metric scale.

Prior Knowledge: How to measure with a metric ruler.

Notes for the Classroom

Introducing the Task

Students' first responses to this task may be, "Ooo, gross!" To help them settle in to the task, you may want to ask them about the last time they had a wound that took time to heal. They may tell stories about skateboarding accidents, getting a carpet burn, or a time when they accidentally cut themselves. Help them realize that wounds are a part of life and that biomedical researchers help us understand how to help our wounds heal.

Some students may be curious about the photographs in the task. They are taken from a study using white rabbits to evaluate the performance of treatments used to accelerate and improve the healing process for wounds. The difference in appearance of the skin around the wound from photo to photo is a result of the healing process. The light areas are healed tissue and the darker areas are scabs.

During the Task

As the students make measurements from the photographs, discuss the use of linear measurements as an approximation to the irregular border of the wound. Let the students know that researchers in medicine and engineering use this same idea of approximate linear measurements to study real-world wound problems.

Today	1 week	2 weeks
36 mm × 36 mm	30 mm × 30 mm	24 mm × 24 mm

Most students will see a decreasing pattern with equal amounts of shrinking in both the width and length direction. The students should infer that the wound will heal in 6 weeks. Ask the students if they can express a rate of healing in mm/week.

The students should develop linear relationships with respect to time. Some students may approach the problem as a relationship between side length and time, as each side begins at 36 mm and reduces by 6 mm overall (3 mm from each end) each week. Other students may approach the problem as a relationship between perimeter and time. In this case the perimeter begins at 4×36 mm because the wound has four sides of equal length and each of the four sides reduces in length by 6 mm each week. Other students may try to develop a relationship between area and time. Note that the relationship between area and time is not linear. You may wish to investigate this non-linear relationship with the students by having them plot Area versus Time on a graph. Have the students compare this graph to graphs for Length versus Time and for Perimeter versus Time. You may have a student who continues to search for a linear relationship between area and time that discovers that the relationship between the change in area from week to week and time is linear. Your students may discover other interesting ways to think about this problem, so have the students explain any relationships that they have developed. This discussion of different approaches can be used to prompt students to look at the problem in a new way or to explore geometric and graphical relationships further.

Each of the relationships discussed above, can be used to show that the healing time for the 18 mm wound is 3 weeks and for the 60 mm wound is 10 weeks. If students are having trouble finding a pattern, you may

suggest that they look at the problem as an increasing pattern from the completely healed state to the wound at the present day instead. The area and perimeter relationships may also be explored using colored tiles. Have the students investigate the graph for the equation they have developed. Many relationships are linear and you can have the students relate the slope and intercept to the changes in the wound. Some relationships are non-linear. The concept of congruent figures or shrinking figures can also be explored.

Other concepts to explore:

What is the difference between growing and shrinking?
How would this work for three-dimensional wounds rather than the two-dimensional case presented here?

Notes:

Focus on Career and Real World Applications:
Biomedical Engineers, like Dale Feldman, Ph.D. at UAB, lead the medical community in developing new techniques to evaluate and to improve wound healing. Researchers use skin grafts, electrical stimulation, and tissue engineering to improve the healing process. Engineers track the rate of healing by measuring the wound at regular intervals. They evaluate the progress of several patients and several treatment methods and compare the results to evaluate exciting new treatment options. The results of their work are shared with doctors and hospitals to improve wound care across the world. *For additional information, contact Dr. Feldman at dfeldman@uab.edu or visit http://www.biofisica.net.*

Other real world growing and shrinking problems:

- Time for a plant or algae to spread over a water reservoir or water source (Civil Engineers)
- Time for a crystal or crystalline structure to grow (Materials Engineers)
- Time for sound to travel from a single source to some point at a distance (Mechanical Engineers)
- Time for a ripple in water, or a wake, to travel from one point to another (Aeronautical Engineers)
- Time for cells to cover a cell-culture dish, or “reach confluence” (Biomedical Engineers, biologists, health related professions)

***K-12** Information **on** Careers in Engineering*

- National Academy of Engineering, Engineer Girl: http://www.engineergirl.org
- American Society for Engineering Education, K-12 Center: http://www.engineeringk12.org/
- American Society for Engineering Education, Go for It!: http://www.engineering-goforit.com/

Application Task #1

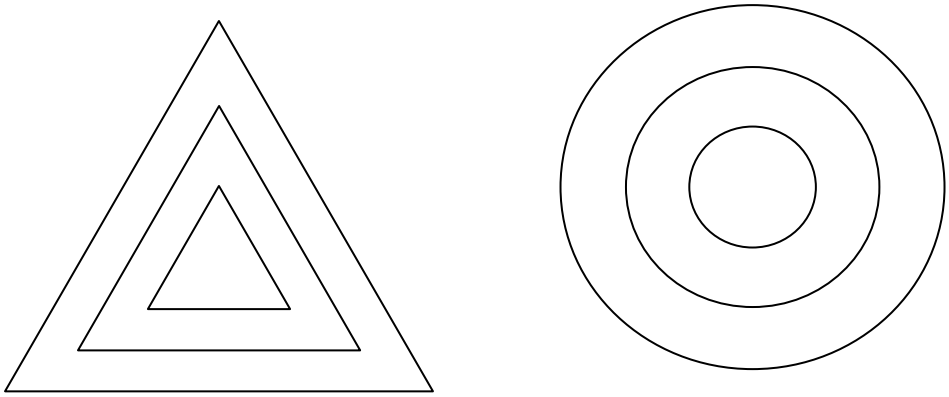
Wound Healing

Challenge:

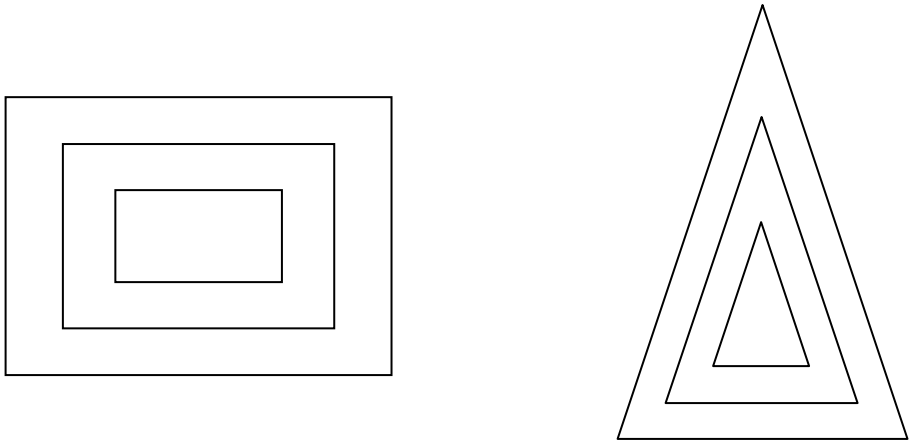
Rate of Healing:

How would you determine how long it take a wound of the shapes shown in sets A and B of any size to heal?

A.



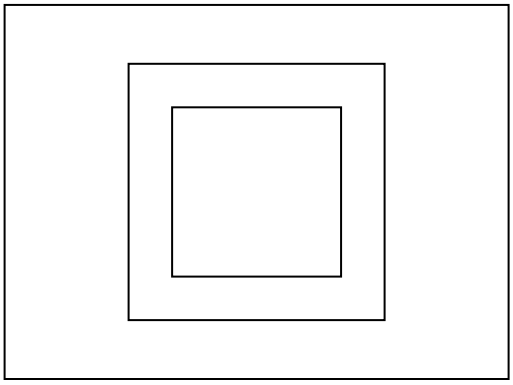
B.

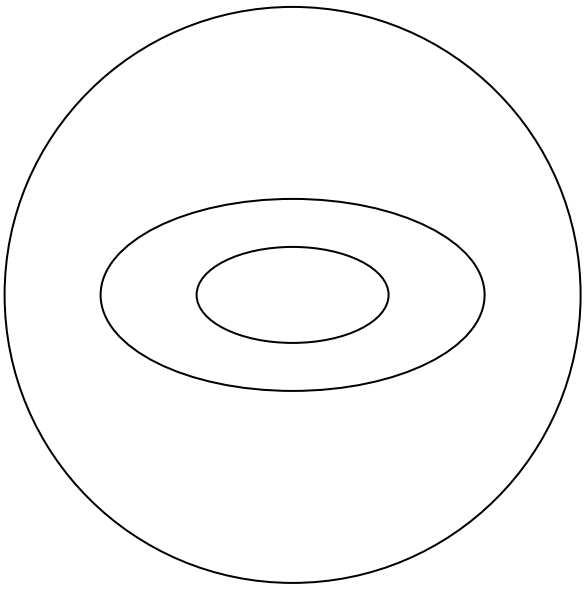


Application #1 Dessert

Wound Healing

What is the rate of healing for the following wound shapes and healing patterns?





Application Task #1
Wound Healing
(8th Grade)

Grade specific concepts addressed

Category	6th	7th	8th
Algebra	Solve problems using numeric and geometric patterns	Express a pattern shown in a graph or chart using an algebraic expression; Translate verbal phrases into algebraic expressions	Plot linear functions; Solve problems involving linear functions
Geometry	Identify 2-D and 3-D figures based on attributes, properties, and component parts	Determine the transformation of a polygon on the coordinate plane; Recognize geometric relationships among 2-D objects	Compare quadrilaterals, triangles, and solids using their properties and characteristics
Measurement	Solve problems involving perimeter and area of parallelograms and rectangles	Solve problems using circumference and area of circles; Find the perimeter of polygons and the area of triangles and trapezoids; Solve problems using ratios or rates using proportional reasoning	Find the perimeter and area of regular and irregular plane figures
Data Analysis	Interpret information from graphs		

Investigations

Category	6th	7th	8th
Algebra	Decreasing pattern relates to time for a variety of shapes	Graph area and perimeter over time and interpret	Plot changes in area and perimeter as well as the rates. Change in area over time is non-linear.
Geometry		Understand dilation (increasing) and shrinking (decreasing) transformations for a variety of shapes	Understand dilation (increasing) and shrinking (decreasing) transformations for a variety of shapes. Do the relationships work for other shapes?
Measurement	How do area and perimeter change over time?	Use dessert problem or focus on changes in area and perimeter over time	Use challenges and/or dessert to get healing rate
Data Analysis	Plot area vs. time. What does the slope of the graph mean?		