LEARN & M^{4}CTE PROJECT GUIDES

Integrating Mathematics and Other Disciplines with Career & Technical Education

Maine MATHEMATICS and SCIENCE Alliance

LEARN & M4CTE PROJECT GUIDES

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This guide, as well as additional resources, can be found on the Maine Mathematics and Science Alliance's website (http://mmsa.org/highlights/learn-m4cte-project-guides)
If you have any trouble viewing the materials please contact us.

The contents of this publication were developed under a grant from the US Department of Education administered by the Maine Department of Education (Grant Award #84.336 Mathematics and Science Partnerships). However, those contents do not necessarily represent the policy of either the US Department of Education or the Maine Department of Education, and you should not assume endorsement by the Federal or State Government.

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Preface

The Learn, Experience, Apply in a Regional Network (LEARN) Mathematics and Mid-Coast Maine Mentoring Mathematics and Career Technical Education (M^4CTE) programs create regional professional learning communities that bring together Career & Technology Education instructors with middle or high school teachers to develop curriculum units. Teachers collaboratively plan and co-teach multi-day lessons that integrate mathematical concepts and theory with practical, hands-on applications. Self-reflection and feedback from colleagues helps teachers make sustained improvements to their practice while experienced leaders serve as mentors to new teacher participants.

These projects are designed to improve teacher content knowledge, content specific pedagogical knowledge and skills, and instructional practices in the areas of measurement and approximation, data analysis and statistics, and probability with the expected outcome of improving student achievement in these content areas. Students have the opportunity to carry out investigations, collect data, and/or perform research to demonstrate achievement as they complete individual or group projects.

The National Assessment of Educational Progress (NAEP), also known as the Nation's Report Card, revealed that teachers who conduct hands-on learning activities on a weekly basis outperform their peers by more than 70% of a grade level in math and 40% of a grade level in Science. (U.S. Department of Education, 1999) As implied by the NAEP, teachers participating in the LEARN and M^4CTE projects reported student results that indicated significant gains in mathematics and, in some cases, science. Beyond improving student achievement, teachers and students involved in the LEARN and M^4CTE projects reported greater student engagement as well as a sense of satisfaction from collaborating with other teachers.

The project guides in this publication are intended to give inspiration and guidance to teachers who are looking to develop collaborative units that include mathematics and career and technical education. The project guides contain a wealth of resources that can be used as is or adapted to fit particular partnerships. All projects in this publication have the intended outcome of improving student engagement, participation and achievement.

Project Leadership

Margaret (Meghan) Southworth- Elementary and Secondary Education Act Title II Coordinator, and Maine Mathematics and Science Alliance Mathematics Specialist and LEARN & M⁴CTE Project Director 2011-2012

Irene Haskins- Maine Mathematics and Science Alliance Mathematics Specialist and Lecturer, School of Sciences and Humanities, Husson University

Dr. Margaret Wycoff- Project Consultant and Professor of Education Emeritus, University of Maine at Farmington

Dr. Lori Koban- Project Consultant and Associate Professor of Mathematics, University of Maine at Farmington

Introduction

The project guides in this collection are descriptions of curriculum units developed by participating teachers in the Learn, Experience, Apply in a Regional Network (LEARN) Mathematics and Mid-Coast Maine Mentoring Mathematics and Career Technical Education (M⁴CTE) professional development programs during the 2011-2012 school year. The LEARN and M⁴CTE programs were funded as part of a grant awarded to the Maine Mathematics and Science Alliance (MMSA) by the Maine Department of Education with funding from the United States Department of Education's Math-Science Partnership Program. Eight school units, including Bangor Christian Schools, Brewer School Department, Maine RSU 13, Maine RSU 26, Maine RSU 34, Maine SAD 40, Mid-Coast School of Technology and United Technologies Center, with faculty and professional development partners from the University of Maine at Farmington (UMF), Husson University and the Maine Mathematics and Science Alliance participated in these professional development programs.

The teachers who participated in the M⁴CTE and LEARN programs were made up of a variety of 6-12 content area specialists, including Mathematics, Science, English, Special Education and numerous teachers from Career & Technical Education (CTE) schools. Through the programs, small teams of teachers utilized the Understanding by Design model of developing curriculum units to work together to plan and co-teach innovative, engaging lessons that incorporated their subject area of expertise and mathematics. Each teacher team included at least one Career & Technical Educator that allowed groups to highlight real-world, hands-on application of

mathematics content. The programs included professional development on curriculum development, lesson specific content knowledge, content specific pedagogical knowledge and skills and instructional practices in measurement and approximation, data analysis and statistics and probability.

Project directors Meghan Southworth and Irene Haskins consulted with Dr. Margaret Wycoff, Professor of Education Emeritus, University of Maine at Farmington and Dr. Lori Koban, Professor of Mathematics, University of Maine at Farmington on the development of specially designed professional development for the participants in the M^{4}CTE and LEARN programs. Throughout the process of creating their curriculum units, teachers collaborated in a regional Professional Learning Community monthly where they engaged in lesson development and lesson specific professional development. Teachers particularly valued this collaboration time when they were given an opportunity to work with a variety of other teachers to evaluate and highlight the inherent overlap in their individual content areas, real-world and industry applications and mathematics.

Work accomplished during the monthly Professional Learning Community time had far reaching affects. While teaching their collaborative units, teachers noted that the incorporation of real world and hands-on content resulted in increased engagement and achievement by students in their classes and an overall sense of purpose driving learning. Teachers encouraged students to challenge themselves by exploring a variety of skill sets that are atypical in the typical classroom including metals manufacturing, computer animated design, forestry and building construction all while fostering their understanding of mathematics. In addition to the great project based learning that took place in classrooms across the state, teachers and students alike also learned about the variety of options available at Career Technical Education schools throughout Maine and how they can incorporate those options into their future educational experiences.

As you read these project guides, please consider how you might incorporate, or encourage the incorporation, of some of the aspects of these particular lessons in classrooms in your area. Every public high school in Maine has a Career Technical Education school to which they are encouraged to send students. The educators working at Maine's CTE schools are unique teachers, they have industry experience as well as experience working with Maine youth. Partnerships, such as the ones fostered by the M^{4}CTE and LEARN programs, which integrate content skills with real world, hands-on applications are not only more interesting and engaging for students, but they are vital to the success of our students in the global community.

~Jessica McGreevy, M^{4}CTE and LEARN Project Director 2012-2013

Boards and Cords: The Mathematics of Forest Sustainability

By Irene Haskins, edited by Jessica McGreevy

Project Developers

- Jeff Beswick, Environmental Horticulture Instructor, United Technologies Center, Bangor ME
- David Jefferies, Special Education Teacher, Brewer High School, Brewer ME
- Stacy LaBree, Special Education Teacher, Brewer High School, Brewer ME

Looking for a great project that involves mathematics, science, forests, making something and gets students outside involved in a very hands-on activity? This is it!

Preface

When you look at tree, would you know how to measure its diameter and height? If the tree is very small, then getting those measurements might be fairly easy. What if the tree towers high above you? Suddenly, the measurements might not be easy at all. What about measuring an entire stand of trees? How would you go about trying to determine how much marketable wood that stand of trees contains? If timber is harvested from the land, how can it be done in a sustainable way? These questions need to be answered when assessing the value and potential use of land. In a state like Maine, where forestry is a major industry, these are especially relevant questions that are encountered often. Mathematics and science play key roles in answering these questions.

A Biltmore Stick

Why Do This Project?

This project uses mathematics and science to help students understand how trees are measured in terms of marketable wood and what actions need to be taken to assure that forests are sustainable. In the end, students will apply problem-solving strategies to analyze a real life situation and gain a better understanding of forestry.

This project was developed as a collaboration between two "regular"[1] high school special education teachers and a horticulture teacher at a Career Technical Education (CTE) school. The partnership was an integral and valuable part of the project, but this project can be utilized in any classroom setting because it makes use of a simple tool that students make themselves.

Best of all, this project provides a fun and interactive connection to the following Standards:

Common Core State Standards for Mathematical Practices:

- *CCSS.Math.Practice.MP2- Reason abstractly and quantitatively.*
- *CCSS.Math.Practice.MP4- Model with mathematics.*
- *CCSS.Math.Practice.MP5 – Use appropriate tools strategically*
- *CCSS.Math.Practice.MP6 – Attend to precision.*
- *CCSS.Math.Practice.MP7 – Look for and make use of structure.*

Common Core State Standards for Mathematics:

- *CCSS.Math.Content.HSS-1C.A.1 –Understand statistics as a process for making inferences about population parameters based on a random sample from that population.*

Overview of the Project

The key to this activity is the use of simple tools like a penny and a calibrated piece of wood called a Biltmore stick. Determining which trees to measure is done using a penny, and the Biltmore stick is used to estimate the height and diameter of a tree.

Use of Biltmore sticks can be traced to the late 1800's and they are still employed today. The first Biltmore stick was developed at the Biltmore Estate in North Carolina. The estate was one of the first places in the United States where forestry was considered a science. Use of a Biltmore stick is one method to determine tree height and diameter and one that is easy for students to construct and learn to use. Using a Biltmore stick, measurement of trees is accomplished using an indirect method. Measurement data is read into tables to estimate the number of boards that can be cut from a given tree. The number of boards can then be translated into number of cubic feet of lumber and subsequently be assessed an estimated value. By making measurements of randomly selected trees, it's possible to estimate the marketable timber value of a piece of land.

This project is about more than just taking measurements. It incorporates algebra, trigonometry, use of random sampling and statistics and learning some of the science behind forestry and sustainability of our forests. Students pull all of this together by developing forest management plans.

[1] The term "regular" high school is meant to distinguish a traditional high school from a Career Technical Education high school. The same term will be used for students attending these schools. There is not an easy way to identify these students from the CTE students, so the word "regular" will be used for clarity.

What Will Students Learn?

- The importance and need of measuring in forestry
- How to use a Biltmore stick to measure trees
- How to use indirect measurement, trigonometry and algebra to find the height of a tree
- How to determine the number of 16 foot boards in a standing tree
- How to determine the number of board feet in a given tree and in a given plot of land
- How to find the amount of cordwood (cubic feet) in a standing tree
- How to access and use Google Earth
- How to use random sampling/probability
- What makes forests sustainable
- What makes land valuable from a timber perspective
- How to collect, analyze and display data

Where's the Math?

In this project, students employ statistical methods, data collection, indirect measurement techniques and trigonometry to analyze and model a real world situation.

The Benefits of Collaboration for This Project

This project was developed as a collaboration between two special education teachers and an environmental horticulture instructor at a CTE school. The CTE instructor provided horticultural and forestry expertise, while the high school teachers provided mathematics expertise. These teachers formed a cohesive team who worked together to develop the activities and lesson plans. They met monthly to jointly work on their plans.
This partnership was valuable to students at both schools, giving them an opportunity to see how math, science and the technical trades come together in a real life situation. The CTE school's horticulture students were able to see how math is used in forestry. Had they ever imagined themselves using trigonometry or statistics in horticulture? The regular high school students had a chance to see their peers in technical education use the same mathematics that they study in class, but in a real world application. Students from both schools participated in all of the activities.

Toolkit – Everything You Need to Do This Project

This section describes four suggested activities for this project. Supporting materials can be found in the Resources/References section of this paper. The activities are examples of what teachers at Brewer High School and United Technologies Center created for their students. This project could easily be adapted by any CTE and regular math teacher partnership to fit their specific needs.

Activity 1: Biltmore Stick Construction

Overview of Activity: For this activity, regular high school students team up with CTE students at the CTE school to make their own Biltmore sticks. Students will be introduced to the project and learn what a Biltmore stick is and how it can be used. Each student will be given a binder of materials for the project. They will use this binder at each of the activities. At the conclusion of the activity, each student will have a completed Biltmore stick and will have calculated their pace length.

Time Frame: This activity is estimated to take about 4 hours total time, not including transportation time.

Materials List

- Tape
- Scissors
- Binder of materials (one per student)
- Permanent markers (fine/medium points)
- 1" x 1" x 25" wood sticks (one per student)
- Pre-test

Things to Do before Activity:

- Have CTE students cut and sand 1 inch by 1 inch by 25 inches sticks. One stick per student.
- Prepare Pre-Test: Include questions on random sampling, indirectly finding the height of a tree using its shadow, what makes a tree more valuable in terms of timber, understanding the amount of lumber a tree contains, estimating the number of cord wood from diameter and height, definitions used in the forestry logging industries, methods of sustainable forestry.
- Prepare binders – suggested contents: (See examples of materials on website).
    - Calendar with a schedule of planned activities for the project
    - Objectives for the project
    - Journaling Instructions (e.g., write about something they learned in the activity, and the current weather conditions and temperature)
    - Notebook paper for journaling
    - Vocabulary Definitions
    - 3 blank vocabulary worksheets
    - Missouri Forest Keepers Network pamphlet about Biltmore sticks and forestry. This pamphlet also contains the templates needed for marking a Biltmore stick.
- In a hallway, near the classroom where the activity is held, mark off a distance of 66 feet. Students will use this to count how many steps they need to take to cover a distance of 66 feet.

Students building Biltmore Sticks.

Activity Details:

Discussion Points:

- Why are we doing this project?
- What is a Biltmore stick? How is it used? Why is it used? What are the markings on the sides of the stick?
- What is forest sustainability? Why is it important?
- What does this project look like? Go over what the project and the upcoming activities.
- What do students need to include in their journal?

Things To Do during Activity:

1. Project Binders: Each student will receive a project binder. After passing the binders out, go over the purpose of the project, upcoming activities, student expectations and the day's activity.
2. Make Biltmore Sticks: Each student will be given a template and a blank Biltmore stick. Students will cut out the templates and tape them to the sticks. This will allow them to easily transfer markings to the sticks using permanent markers. All four sides of the stick will need to be marked. One side will have measurements that can be used to measure the diameter of a tree at breast height; another side provides measurements needed to determine the height of a tree. The two remaining sides will contain tables that can be used to determine the board feet and the number of 16-foot logs that can be cut.

   Note: Biltmore sticks can also be made from yardsticks, but the advantage of the square sticks is the ability to add table information on the remaining sides of the stick. This table information gives students a complete tool, just like what would be used in the field.
3. Determine Number of Steps. Tree height measurement is taken at a distance of 66 feet from the base of a tree. In the field, the 66 feet is measured by number of steps. Students will need to do the same when they make their tree measurements. Have each of the students walk a distance of 66 feet and count how many steps they take.

Conclusion of Activity: The day's activity concludes with recapping the key points of the day, followed by students writing in their journals for 10 minutes. Students should also record the number of steps it took them to walk 66 feet. They will need this in Activity 3.

Activity 2: Forests and Sustainability/ How to Make Measurements

Overview: In this activity, students learn about forests and forest sustainability as well as how to use their Biltmore sticks and, if available, a clinometer to collect data on trees. Utilizing a forestry expert is recommended for this activity. They can discuss what makes a forest healthy, forest sustainability, and good forestry practices. The teachers who developed this project had students meet with an expert at the University of Maine Forest Garage. An alternative would be to have an expert come to the school, as long as there is a wooded area nearby so students can practice taking measurements. If using an expert on forestry is not an option, the teachers can cover the same material.

Time Frame: Depending on location, this activity is estimated to take between 3-5 hours total time. As an option, this activity could be split into two separate activities – one to learn about forest sustainability and one to learn and practice taking measurements using the Biltmore sticks.

Materials List:

- Biltmore sticks
- Clinometer (if available)
- Data Collection Sheets
- Student Binders

Things to Do before Activity:

- In individual classrooms cover the following:
  - How to use and read a Biltmore stick
  - Forestry vocabulary
- Make Data Collection sheets - For each tree measured students need to record the following:
  - Diameter at breast height
  - Number of board feet
  - Number of marketable logs
  - Number of cord of wood
  - Description, research and notes

Activity Details:

Discussion Points:

- Forest Health – what makes a forest healthy?
- Forest Sustainability - What practices can be employed to assure sustainability?
- How does reseeding, clear cutting, thinning, overstory, parasites and infestations impact a forest?

- If available, discuss how to use a clinometer to find the angle of elevation between the person making the measurement and the top of the tree to be measured. This is an alternative way to measure the height of trees.

- How to use a Biltmore stick determine the width and height of a tree.

- What is the difference between direct and indirect measurements?

- Why would you use indirect measurement?

- Discuss the process students will need to use to determine tree height, using the tangent of the angle of elevation and algebraic principles to solve for the height of a tree.

- Show students how to use tables for Biltmore Sticks to calculate the number of 16 foot boards that can be harvested from a tree, (Note: the tables were part of the templates that students transferred to their Biltmore stick in Activity 1.)

Things to Do during Activity:

1. Forest Health: Have a forestry expert discuss forest health, sustainability, aspects that impact forests.

2. Use of Biltmore Stick/Clinometer: Have forestry expert explain the use of a Biltmore stick and clinometer.

3. Measure Trees: Working in groups of 3 or 4, have students practice using a Biltmore stick and clinometer (optional) using nearby trees. Each group will measure a nearby tree and find the following:
    a) Height of the tree
    b) Angle of elevation
    c) Diameter at breast height
    d) Number of 16 foot logs in the tree
    e) Number of board feet in the tree

4. Record Measurements: Students record measurements on a data collection sheet and perform any required calculations.

Conclusion of Activity:

- Review the discussion points of the day using questioning techniques and impromptu discussion.
- Give students 10 minutes to write in their journals.

Activity 3: Forest Measurement

Overview: The intent of this activity is to have students use their Biltmore sticks to assess the marketable value of a stand of trees. They will use the measurements to develop forest management plans in Activity 4.

Time Frame: This activity is estimated to take about 4-5 hours total time. Not including transportation time.

Materials List

- Pennies
- Biltmore sticks
- Cameras
- Data Collection Sheets
- A trigonometry table showing angles and tangent values

Things to Do before Activity:

- In individual classrooms cover the following:
  - Vocabulary
  - Indirect measurement and proportions
  - How to estimate the value of timber
  - Random sampling using a penny plot.
  - How big is an acre?
- In the forested area, locate and mark approximately 1/10 acre areas for students to measure.

Activity Details

Discussion Points:

- Why do we sample trees to measure instead of measuring every tree in a given area?
- How to determine which trees to measure using a penny.
- What is a partial timber cruise?

Things to Do during Activity:

1. Plot Assignments: Students will be assigned into small groups of 3 to 4, with each group assigned a plot of land that is approximately 1/10 of an acre.
2. Penny Plot: Students will need to conduct a penny plot of their plot of land in order to make their random sample.
3. Measure: Students will use their Biltmore sticks and/or clinometers to find the height and diameter at breast height of their selected trees
4. Photograph: Students will take a photograph of their selected trees.

5. Document: Students will write a description of their plot of land in terms of understory, overstory, seeding, natural growth, etc.

Conclusion of Activity:

- After students complete their forest measurements, they meet back at the CTE school. Teachers will stake out a 3-dimensional representation of cord of wood to show students physical illustration of the size of a cord.

- Using the measurements taken during this activity, students will do the following:
  - Number of Board Feet: For each tree measured, students will use the appropriate table on their Biltmore sticks to determine the number of 16-foot boards each tree will yield.
  - Cubic Volume: Students will then find the cubic volume of each sampled tree and express the result in terms of cords of wood. To do this they will need the diameter at breast height and number of 16-foot boards.
  - Pictorial Representation: Additionally students will create a pictorial representation of their 10 trees as logs.

- The activity concludes with students writing for 10 minutes about the day in their journals.

Activity 4: Forest Management Plans

Overview: Students from both schools meet together at the CTE school to present their final project, a Forest Management and Sustainability Plan. Students will be working in the same small groups they were in from Activity 3. Prior to this activity each group will be told that they have inherited 100 acres of forest and need to determine what they want to do with this land. One factor they need to consider is the estimated marketable timber value of the land. Students will use the sample data they collected in Activity 3 to represent their inherited land. Their analysis of the data becomes the basis for their Forest Management and Sustainability Plan.

Time Frame: This activity is estimated to take about 3-4 hours total time. This does not include transportation time.

Materials List:

- Forest Management Final Project Instructions
- A trigonometry table showing angles and tangent values, if a clinometer is used.
- Post-Test

Things to Do before Activity:

The following needs to occur in the individual classrooms prior to Activity 4:

- Provide students with instructions for their final project: the creation of a Forest Management and Sustainability Plan.
- Cover how to estimate the timber of a plot of land.
- Cover how to extrapolate data from their sample data. For example, (1/10 of an acre to 100 acres).
- Provide research and in-class work time on the forest management plans.
- Each of the small student groups will create their Forest Sustainability /Forest Management Plan.

- Forest Management Final Project Instructions. Using what they've learned from this project, students will come up with a Forest Management and Sustainability Plan for the theoretical 100-acre plot of forest that students have "inherited". The plan will incorporate the following:
  - Sustainability Plan – description of how student would sustain the land.
  - Description of the land (owner, location, description of land, current inventory of land, property history, available water, wildlife, an air photo (Google Earth), maps of area, unique features of the property.
  - Forest Management Plan – how will the land be used and why?

- Make Post-Test (use same questions as Pre-Test)

Activity Details:

Discussion Points:

- How did was data used to make conclusions?
- Why is it important to justify a conclusion?

Things to Do during Activity:

1. Oral Presentations: Each group will do an oral presentation of their Forest Management and Sustainability Plan. The groups must include a visual aid (poster, Power Point, etc.) and their presentation needs to cover :

    a. Who is the forest owner? (name, address, contact information)

    b. Where is the property? Description and directions on how to get to the property
    c. What are the forest objectives? How do students envision using the land and why?
    d. Inventory of the land – current cover, history, wildlife habitat conditions, copy of air photo (Google Earth), pre-printed maps (internet or other sources), and any unique features of the land.
    e. How will the land be sustained?

2. Written Papers: Each group will turn in a written copy of their Forest Management Plan based on the final project instructions.

Conclusion of Activity:

- Students take Post Test (same test as used for pre-test)
- Students will write their last journal entry for the project.

Suggested Field Trips:

- Visit a Forestry Expert or invite one to your school.

  The teachers who developed this project arranged a trip to the University of Maine Forest Garage. While there Professor Alan Kimball, University Forest Manager, gave a tour of the facilities and surrounding woods and presented a lesson on forest sustainability. He explained the processes to maintain a healthy and profitable forest. Other topics covered included the principles of natural seeding, the impacts of forests that are not reseeding, clear-cutting, thinning, the overstory, parasites and infestations.

Resources/References:

There are many good resources for information on forestry management and Biltmore sticks. The sites below were used by the teachers who developed this project and by the author for additional background for this document.

1. Extensive material relating to goals, objectives, lessons, activities, and other supporting documents was provided by the three instructors who developed this project: Stacy LaBree, Jeffery Beswick and David Jefferies.

2. Missouri ForestKeepers Field Guide on Biltmore sticks. This brochure contains a wealth of information on how to make and use a Biltmore stick, take penny plots, identify tree species, rate the health of a tree using foliage, limbs and the crown, make observations, perform area analysis, make samples. Also provided is a glossary of terminology. www.forestkeepers.org

3. The Biltmore Stick – A Tree Measurement Tool by Tech Tree Consulting www.tree-tech.com

4. Measuring Tree Volume with a Biltmore Stick, Utah State University, Cooperative Extension. http://forestry.usu.edu/htm/rural-forests/forest-management/forest-timber-management/measuring-tree-volume-with-a-biltmore-stick/

5. Maryland State Envirothon Resource http://www.dnr.state.md.us/education/envirothon/forestry/measurements.html

6. RT Bot. This site contains some good background on Biltmore sticks and forestry in general. http://www.rtbot.net/Biltmore_stick

7. National Center for Research in Vocational Education – University of California at Berkley: This website has a write-up and recommendations for forming collaborations between regular schools and technical education. The paper was written in 1993, but is still very relevant today. http://vocserve.berkeley.edu/centerfocus/cf2.html

Examples and additional materials mentioned in this project can be found at http://mmsa.org/highlights/learn-m4cte-project-guides

Electrical Circuits and the Human Brain

By Irene Haskins, edited by Jessica McGreevy

Project Developers:

- Elizabeth Drury, Mathematics and Science Teacher, Medomak Valley Middle School, Waldoboro ME
- Monique Moreau, CAN/Medical Science Instructor, Mid-Coast School of Technology, Rockland ME
- Glenn Wooster, Small Engine Repair Instructor, Mid-Coast School of Technology, Rockland ME

Is there a connection between electrical circuits and the human brain? It turns out that there is! This is an exciting and unique project where students will learn how different areas of science interconnect. Along the way, students will use mathematical modeling and see its application in the study of neural diseases.

Preface

This project uses a skeleton that has been wired with electrical circuits and lights. The skeleton circuitry has been programmed to show which areas of the body are impacted by certain diseases. While the skeleton is the very visible part of the project, there is much more to this project in terms of mathematics and science.

This is a photo of the skeleton used by the teachers who developed this project. The skeleton is suspended inside a locker and can be easily transported using a dolly. The skeleton has been wired with lights and programmed to show how specific diseases impact different parts of the neural system. This provides a very powerful visual image to enhance student learning.

Through the project, students learn how the human brain sends messages to the nervous system and how electrical circuits work.

Why Do This Project?

This project provides a fun and attention-grabbing way to help students see the connection between electrical circuits and the human neural network. A skeleton is used to help the students see how various medical conditions impact specific areas of the nervous system. Graphing and modeling are employed to help students display and visualize the spread and pattern of neural diseases over populations. Students will learn about the correlation between electrical pulses in the brain and the flow of electrons in an electrical circuit. They will also learn about the basics of electricity and how to compute electrical equations. In essence, this project incorporates physics, biology and mathematical concepts in a seamless, cross-curricular lesson.

This project was developed as a collaboration between a mathematics teacher from Medomak Middle School (Waldoboro, ME) and two instructors from the Mid-Coast School of Technology (Rockland ME) representing small engine repair and health sciences.

This project provides connections to the following Common Core State Standards (CCSS):

Common Core State Standards for Mathematical Practice:

- *CCSS.Math.SMP.2- Reason Abstractly and Quantitatively*
- *CCSS.Math.SMP.4 – Model with Mathematics*
- *CCSS.Math.SMP.5 – Use appropriate tools strategically*
- *CCSS.Math.SMP.7 – Look for and make use of structure.*

Common Core State Standards- Mathematics:

- *CCSS.Math.6.SP.A.2- Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.*
- *CCSS.Math.6.SP.B.4- Display numerical data using a number line, including dot plots, histograms, and box plots.*
- *CCSS.Math.6.SP.B.5- Summarize numerical data sets in relation to their context, such as by:*
    - *CCSS.Math.6.SP.B.5a- Reporting the number of observations.*
    - *CCSS.Math.6.SP.B.5b- Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.*
    - *CCSS.Math.6.SP.B.5c- Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.*
    - *CCSS.Math.6.SP.B.6d- Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.*
- *CCSS.Math.7.NS.A.1a- Describe situations in which opposite quantities combine to make 0.*

- *CCSS.Math.7.NS.A.1b- Understand p+q as the number located a distance |q| from p, in the positive or negative direction depending on whether q is positive or negative. Show that a number and its opposite have a sum of 0 (are additive inverses). Interpret sums of rational numbers describing real-world contexts.*
- *CCSS.Math.7.NS.A.2c- Apply properties of operations as strategies to multiply and divide rational numbers.*
- *CCSS.Math.7.EE.A.2- Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related.*
- *CCSS.Math.7.EE.B.3- Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimate strategies.*
- *CCSS.Math.7.EE.B.4- Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.*

Overview of the Project

This project is unique in the way it pulls together mutliple branches of science with mathematics using a skeleton as the centerpiece. CTE students pre-wire a skeleton with strategically placed lights to simulate neurological paths from the brain to parts of the body. The skeleton becomes the centerpeice of the project and will help students reinforce what they have learned in the areas of electricity, the human brain and neurological disease.

This project incorporates lessons on electricity (Ohm's law and circuit boards), the human nervous system and diseases, graphing and mathmetical modeling. Pre- and post-tests are employed to assess student understanding of the project objectives.

What Will the Students Learn?

Students will learn how to:

- Define and apply Ohm's Law.
- Determine the best graphical representation for various kinds of data.
- Analyze trends in graphs and make inferences based upon the data.
- Build their vocabulary of scientific and mathematical terminology.
- Construct and label a circuit board (CTE students).
- Develop graphs of neural diseases and populations.

Where's the Math?

In this project students will learn about and practice using basic electrical equations with proper units. They will use mathematical modeling to visualize the spread and patterns of neural disease in a population. They will also employ graphing and statistical inferences as part of this project. Number system concepts such as Order of Operations are employed through use of calculations such as Ohms Law.

The Benefits of Collaboration for This Project

The challenge in developing this project was to find a way to bring together middle school math and science students and CTE students in CAN/Medical Science and Small Engine Repair into a project that ties all these areas together. The teachers found a great common ground in the correlation between electrical circuits and the brain's electrical system!

Such a collaboration was valuable to the students at both schools by giving them an opportunity to see how math, science and the technical trades come together to model real life. The students were able to see how electrical circuits and the human brain have similarities. They were also able to learn about certain diseases and how to graph and model data that can be used to make predictions in the real world.

The Small Engine Repair CTE instructor provided the electrical circuitry expertise, while the CAN/ Medical Science CTE instructor provided the expertise on the human brain, nervous system and diseases. The middle school teacher provided the mathematics expertise. Background in all three of these areas was needed to successfully develop this curriculum, and the three teachers involved combined their expertise to make this project a success.

The following are reflections from the three teachers involved in this project:

Monique Moreau's Reflections: "Glenn brought to life the correlation between an electrical system and the body. We actually used Common Core Standards relating medical conditions to problems in electrical circuits."

Glenn Wooster's Reflections: "When you try to work with something you think you don't know, you find you know more than you thought."

Elizabeth Drury's Reflections: "To see adults carrying on conversations and making connections was enriching. This project made the body's electrical system visible."

Toolkit – Everything You Need to Do This Project

This section describes joint school activity for this project. Support information for the project can be found in the Resources/References section of this paper. Not included in this section are details regarding the wiring of the skeleton. It is assumed that this task is part of the standard CTE curriculum.

This activity is an example of what the teachers at Medomak Middle School and the Mid-Coast School of Technology put together for their students. This project could easily be adapted by any CTE and math teacher partnership to fit their specific needs.
This activity was set up to take place at the CTE school. This allowed the middle school students a rare opportunity to see the various kinds of programs offered at the CTE school.

Activity Description: Electrical Circuits and the Human Brain

Overview of Activity: This activity brings together middle school and CTE students at the CTE school. The activity entails three segments. The first segment includes a "get to know you" exercise, a pre-test and lessons on medical science and circuitry. The middle school students also take a tour of the CTE facility. The second segment includes a quiz game using the skeleton to help students see how certain diseases impact the neural system. The third segment includes a post-test.

Time Frame: Estimated time frame is approximately 4 hours.

Material List

- One skeleton, pre-wired with lights and circuitry to show the nervous system and specific diseases
- 3 black markers, one per team
- Stop watch or other timing device for the time keeper
- Bells, one per group
- 4 sheets of paper per team
- Quiz game sheet – one per team
- Box for students to turn in their quiz game sheets
- Pre- and Post-tests, one per student

Things to Do before Activity:

- Set up skeleton wiring, lighting, and programming. The skeleton will need to be programmed to show the impacted parts of the neural system for specific diseases. (Note: The CTE small engine students would complete this work prior to meeting with the middle school students.)
- Design game for quiz
- Design a "get to know you" activity
- Design a Pre- and Post-test (basic structure of nervous system, resistance of a circuit, identify graph for the relationship between volts, amps and Ohms.)

Project Details:

Discussion Points:

- How can I use what I learned today about how electrical circuitry and the human nervous system operate and apply it to other situations in nature?
- Can I think of other systems of science that might be related and develop a comparison and contrasting statement about them?
- How can I make a mathematical model to fit what I see happening in science or nature?
- How to interpret scatter plots.

Things to Do during the Activity:

The activity is set up in three segments:

1. First segment: All students meet together and participate in a "get to know you" activity. The students are then separated into 3 groups that will rotate through the following:
   a) Medical Science Activity
   b) Tour of CTE school
   c) Circuitry (Ohms Law)
2. Second Segment: Quiz Game – The skeleton is used for a quiz which takes about 15 minutes. The students remain in their designated groups. The students are told to watch the skeleton and that the lights will indicate what parts of the neural system are impacted for a given disease. The groups will have 10 seconds to identify what medical condition the skeleton is showing. After each answer is given, there is a short discussion summarizing what is happening with the neural system circuitry specific to the given disease. This same process is repeated for the remainder of the diseases to be covered. If all three groups make the correct identification, it is considered to be a three-way tie.
3. Third Segment: Post-Test- Each student is given a Post-Test.

Conclusion of Activity: The activity concludes with the Post-Test.

Resources/References

1. Material related to goals, objectives, activities and other supporting documents were provided by the three instructors who developed this project: Liz Drury (Math/Science - Medomak Middle School), Glenn Wooster (Small Engine Repair Instructor - Mid Coast School of Technology, Rockland ME) and Monique Moreau (CAN/ Medical Science Instructor – Mid Coast School of Technology, Rockland ME).

Examples and additional materials mentioned in this project can be found at: http://mmsa.org/highlights/learn-m4cte-project-guides

Key Chains

By Irene Haskins, edited by Jessica McGreevy

Project Developers:

- Rich Barratt, Machine Shop Instructor, Mid-Coast School of Technology, Rockland ME
- Kristy Hastings, Mathematics Instructor, Mid-Coast School of Technology, Rockland ME

Looking for a fun way to work with ordered pairs on the coordinate plane? This is it! Students will create designs that will be translated into ordered pairs and then engraved onto metal key chain tags. The key to this project lies in bringing together mathematics and a real world application in a fun, interactive and unique way.

Preface

If you could create any design of your choice to engrave on a metal key chain tag, what would it be? How would that design be communicated to a computer-based engraving machine? One way would be to use ordered pairs to describe points in the design. This project shows how ordered pairs on the coordinate plane are used in a real life manufacturing application.

Why Do This Project?

This project lets students create a design of their own and then translate that design into a set of ordered pairs that describe the design to a computer. That computer then controls an engraving machine to manufacture the design.

This project was developed as a collaboration between a mathematics teacher and a machine shop teacher, both working at the same Career Technical Education (CTE) school.

While students learn how mathematics arises in machine shops and manufacturing, this project also addresses the Common Core State Standards indicated below.

Common Core State Standards for Mathematical Practice:

- *CCSS.Math.SMP.1 - Make sense of problems and persevere in solving them.*
- *CCSS.Math.SMP.4 – Model with Mathematics*
- *CCSS.Math.SMP.5 – Use appropriate tools strategically.*
- *CCSS.Math.SMP.6 – Attend to Precision.*

Common Core State Standards- Mathematics:

- *CCSS.Math.7.G.1 – Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.*

Overview of the Project

This project mimics the machine shop manufacturing process by creating engraved designs on metal key chain tags. Students are given a set of constraints and then create a design drawing adhering to those constraints.

In this project, math students created the key chain designs, while machine shop students took the role of machinists and programmed the designs on key chains.

This project requires access to OmniGraphSketcher (or a similar graphing tool) and a CNC machine.

What Will Students Learn?

- To demonstrate understanding of machinist work and manufacturing processes
- How to properly use tools for measurement
- How to create a design that meets a given set of constraints
- How to make measurements to the nearest thousandth of an inch
- How to measure using arc measurement
- How to work with scaled diagrams
- How to find the coordinates of points in a design drawing
- How to test the design directions in an OmniGraphSketcher to make sure their directions match their design
- How to write and run a CNC program
- How to write a set of directions for a machinist

Where's the Math?

In this project, students will utilize measurement, ordered pairs in the coordinate plane, arc measurement and scale drawings.

The Benefits of Collaboration for This Project

This project was a collaboration between two CTE teachers (mathematics and machine shop) at the Mid Coast School of Technology in Rockland, Maine. Although this is a unique pairing compared to the other projects, it nonetheless represents a pairing of two generally separate disciplines. Such pairings help math students see how math is used in a real world application and it shows CTE students that their work has roots in mathematics. This project could also work equally well for any pairing of a mathematics teacher and a CTE machine shop teacher. Since specific machine shop equipment is needed for this project, a collaboration with a CTE school is highly advantageous.

Toolkit – Everything You Need to Do This Project

This section describes a suggested activity for this project. Supporting information can be found in the Resources/References section of this paper.

This section is based on what teachers at the Mid-Coast School of Technology developed for their students. Any CTE and math teacher team, to fit their specific needs, could easily adapt this project.

Note: This section describes the work mathematics students do, but does not include specifics about what the machine shop students did to produce the engraved key chain tags. It is assumed that this type of activity is part of their normal curriculum. Because two teachers at the same CTE school developed this project, some of the students benefitted by being involved from both a mathematics perspective and a machine shop perspective.

Activity 1: Key Chain Design

Overview of Activity: Students create a design of their choice and translate it into a set of ordered pairs. The ordered pairs are used to write instructions so a "machinist" can create their design on a metal key chain tag.

Time Frame: Several classes (4 weeks)

Materials List:

- Large graph paper for drawing
- OmniGraphSketcher application
- Large graph paper 10" x 20"
- Direction sheets (see example on website.)

Note: Access to a CNC machine and Engraver machine are required to produce the metal key chains.

Things to Do before Activity:

- Make Pre and Post tests
- Determine criteria for drawing designs. One design constraint is size of the key tags.
- Prepare direction sheets to record ordered pairs and order of the ordered pairs (see example on website.)

Activity Details:

Discussion Points:

- What does a machinist do?
- What types of tools and machines do machinists use?
- What is a CNC machine?
- How would you translate a diagram into a set of usable ordered pairs?
- How to Measure accurately to one thousandth of an inch
- How are curves created using arc measurement and what happens if arc measurement is increased or decreased? Important concepts are start point, end point and radius of arc.
- What is a scaled drawing?
- How to create instructions for a CNC machine.
- How to use the OmniGraphSketcher application.

Things to Do during the Activity:

1. Pre-Test: Students start the activity by taking a pre-test. Suggested topics of the pre-test are:
   a) Measurement accuracy: Determine measurements of several given line segments
   b) Given a drawing, find the coordinate pairs of specified points.
2. Intro to Project: The project is introduced and students are given instructions for their design drawings.
3. Key Chain Designs: When students decide on a design, they will draw it on a large piece of graph paper (10" x 20") using a scale of one tenth of an inch for each 1-inch block.
4. Translate Design to Ordered Pairs: Students will translate their drawing into a set of coordinate pairs. They do not need to translate every point, but they will need to have a minimal number of points that will convey the design. For example, for a straight line, only the two end points need to be defined.

5. Determine Path: Once the appropriate ordered pairs are defined, students will need to determine what path the engraving tool must take to correctly make their design.
6. Write Directions: Students will write a set of directions for the machinist. The directions include the ordered pairs and path of the ordered pairs (i.e., the sequence of the ordered pairs).
7. OmniGraphSketcher: Students enter their directions of ordered pairs into OmniGraphSketcher. This tool will produce a diagram of the design based on the directions. This will allow students to see if their directions were written correctly.

   Note: Once the designs are verified, the directions will be given to the machine shop students, who will be serving in the role of machinists to program the CNC and engrave key chain tags. This work is done separately from this activity.

Conclusion of Activity: The activity concludes with students taking a post-test. This test is the same as of the pre-test and is used to access student learning.

Resources/References:

1. Material relating to goals, objectives, lessons and other supporting information was provided by the two instructors who developed this project: Kristy Hastings and Rich Barratt of the Mid Coast School of Technology, Rockland, Maine.
2. http://www.srcf.ucam.org/~aaa68/ Information on what a CNC machine is.
3. http://www.craftsmanshipmuseum.com/Shoptools.htm – good write-up on what machinists do and the type of equipment they use.

Examples and additional materials mentioned in this project can be found at: http://mmsa.org/highlights/learn-m4cte-project-guides

Math, It does a Body Good: The Mathematics of Nutrition

By Irene Haskins, edited by Jessica McGreevy

Project Developers:

- Carol Pelletier, Culinary Arts Instructor, Mid-Coast School of Technology, Rockland ME
- Sue Watts, Seventh Grade Teacher, Thomaston Grammar School, Thomaston ME

How does nutrition tie to mathematics? This project gives students a chance to see how mathematics impacts their daily lives in ways they might not have considered.

Preface

Nutrition and a healthy lifestyle are important contemporary topics that students are likely to encounter in their daily lives. Do they see that there is a mathematical connection to these topics? In this project students will use mathematics to help them make healthy nutritional decisions. Students will make use of a series of steps called the Engineering Design Process to investigate nutritional questions and create individual nutrition plans.

This project concludes with a "Create Your Own Pizza" activity. This provides a fun way for students to use the nutrition information they've learned to calculate the calories and nutritional content of their own individual pizza creations.

Why Do This Project?

This project was developed as a collaboration between a middle school mathematics teacher and a culinary teacher at a Career Technical Education (CTE) School. While the focus of this project is nutrition, it is the underlying mathematics that is critical to student success. This project gives students a chance to see that math truly does impact their daily lives. The following list comprises the Common Core State Standards that are supported in this project.

Common Core State Standards of Mathematical Practice:

- *CCSS.Math.SMP.1 – Make sense of problems and preserve in solving them.*
- *CCSS.Math.SMP.3 – Construct viable arguments based on evidence and critique the reasoning of others.*

Common Core State Standards – Mathematics:

- *CCSS.Math.7.SP.1 – Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.*
- *CCSS.Math.7.SP.2 – Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.*

Overview of the Project

In this project students learn about the importance of good nutrition and the long term costs of unhealthy eating. They will study childhood obesity and see how obesity rates have changed over time. They will exercise daily and track their resting heart rate before and afterwards. Comparisons will be made between the student's eating habits and recommended nutritional amounts. A web site is used to calculate the nutrients based on their specific weight, gender, age and activity level.

The project culminates in a "Create Your Own Pizza" activity at the CTE school. Students put into practice the nutrition information they've learned about making healthier selections.

What Will Students Learn?

- How to interpret the USDA and US Department of Human Services 2010 Dietary Guidelines for Americans
- How to find the number of calories in a pound of weight
- How nutrition affects health
- How to interpret the food pyramid
- How to calculate personal recommended daily nutritional requirements
- How to collect and analyze personal nutritional data
- How to develop conclusions and justify conclusions with evidence
- How to determine resting heart rate
- How to balance caloric intake and output in a healthy diet
- How to use the Engineering Design Process for collecting and analyzing data
- How to graphically display data

Where's the Math?

In this project students will collect data using the Engineering Design Process. The data will be summarized, interpreted and displayed using graphics. Students will use the data to make inferences. Additionally, through their work, students will use and interpret formulas.

The Benefits of Collaboration for This Project

This project was developed as a collaboration between a middle school mathematics teacher and a culinary instructor. This partnership was an integral and valuable part of the project. Both teachers combined their expertise to create a successful project. Additionally, the CTE school was set up with the necessary cooking and baking facilities.

Reflections on collaboration from Sue Watts, 7th Grade (middle school)[2] mathematics teacher, Thomaston Grammar School, Thomaston, ME and Carol Pelletier, Hospitality-Baking, Mid-Coast School of Technology, Rockland, ME:

1. What do you think the benefits of setting up collaborations between middle schools and the CTE?

   It helps to see what the kids are going to need for skills as they progress in school. I have learned different teaching techniques as well.

2. What worked really well about the collaboration?

   Carol was terrific. Having dates set up ahead of time made it easy to plan and keep organized. Carol and I both had equal input and felt comfortable making suggestions to each other.

3. What didn't work quite so well about the collaboration?

   It would have been nice to have the kids work together more than twice.

4. In particular, how did the students from both schools benefit?

   My kids got to see why they needed these math skills. Carol's kids got experience working with younger students showing them how to do things. They got to see just how much they really knew about nutrition and math.

Toolkit – Everything You Need to Do This Project

This section describes several activities for this project. Supporting materials covering the discussion points can be found in the Resources/References section of this paper.

Some of the activities took place in the middle school classroom prior to two joint activities involving students from both schools at the CTE school.

This is an example of what the teachers who developed this project put together for their students. Any CTE and middle school math teacher team could easily adapt this project to fit their needs.

[2] One of the developing teachers for this project is a 7th grade teacher at a grammar school. Those students will be referred to as "middle school students.

Activity 1: Kick off

Overview of Activity: This activity takes place in the middle school mathematics classroom. Students will read articles on childhood obesity; learn about nutrition, exercise and other healthy lifestyle choices.

Time Frame: Approximately 1 hour.

Materials List:

- Three articles on childhood obesity
- KWL charts (What I know, What I want to know, What I learned)
- Survey forms
- Pre-Test

Things to Do before Activity:

- Prepare survey form for students to record their knowledge about childhood obesity, nutrition and exercise.
- Copy three articles on childhood obesity (see Resources for suggested articles).
- KWL charts (see examples on website)
- Prepare Pre-Test: (see website)

Activity Details:

Discussion Points:

- Childhood Obesity
- Benefits of good nutrition
- Benefits of daily exercise

Things to Do during the Activity:

1. Pre-Test: This activity begins with students taking the Pre-test.
2. Survey: Students complete a survey about their knowledge of childhood obesity, nutrition and exercise.
3. Reading: Using the "Jigsaw" method of cooperative learning, have students read one of three articles on childhood obesity. They will then report their findings to the class.
4. Documenting: Students fill out KWL charts with information they learned from the article they read, as well as the articles read by others.
5. Discuss: Students discuss their ideas about childhood obesity, and generate ideas about how to gather information for the project.

Conclusion of Activity: Activity concludes with a discussion about childhood obesity and generating ideas for gathering information for the project.

Activity 2: Tracking Daily Calories and Activity Levels

Overview of Activity: This activity takes place in the middle school mathematics classroom. Students will be given food/activity logs and log their information for a period of 5 days.

Time Frame: Approximately one hour

Materials List:

- Food/Activity Log sheets (one per student)

Things to Do before Activity:

- Prepare Food/Activity log sheets that students can use to track daily information. (see examples on website)
- Find a website that students can use to track their daily calorie and activity levels. Suggested website: http://www.calorieking.com/

Activity Details:

Discussion Points:

- How to log daily calorie and activity levels
- Discuss web site

Things to Do during the Activity:

1. Log Sheets: Pass out daily calorie and activity level log sheets and explain how they are used.
2. Web Site: Have students log onto the website they'll be using to log their calorie and activity levels. Provide time to explore the website and ask questions about recording their information.

Conclusion of Activity: Activity concludes by asking students if there are any questions or comments. They are reminded that they will need to keep track of their information for 5 to 10 days.

Activity 3: Resting Heart Rate

Overview of Activity: This activity takes place in the middle school mathematics classroom. Students learn how to take their resting heart rate and use Karvonen's Formula to find their target heart rate. It is suggested that this activity take place on a Monday, as students will be exercising in class for 5 days to reach their target heart rates.

Time Frame: Approximately 1 hour for first day, but students will be exercising in class and recording heart rate before and afterwards for a total of 5 days.

Materials List:

- Stop Watch or other timing device
- Target rate worksheet (see examples on website)

Things to Do before Activity:

- Prepare target rate worksheet

Activity Details:

Discussion Points:

- Physiology of the heart and how it works
- Impacts of exercise on the heart
- Why exercise is important to the heart
- Resting heart rate
- Karvonen's formula for target heart rate
- Heart Rate Reserve

Things to Do during Activity:

1. Resting Heart Rate: Explain resting Heart Rate to students and have them find their own resting heart rate. They will write it down.
2. Exercise: Students perform 5 to 10 minutes of strenuous exercise.
3. Heart rate after exercise: Students find their heart rate after exercise and write it down.
4. Target Heart Rate: Students are given worksheet on Karvonen's Formula for target heart rate. Students use the Karvonen formula to determine their own target heart rate.

Conclusion of Activity: Students will spend 5 to 10 minutes of class time strenuously exercising for the next 4 days in class with the goal of reaching their target heart rate each day.

Activity 4: SMART GOAL

Overview of Activity: This activity takes place in the middle school mathematics classroom. In this activity, students will be learning about the importance of macro-nutrients. They will use mathematical formulas to determine their own nutritional needs and they will learn the difference between serving size and portions. They will document their goals using the SMART Goal strategy (Specific, Measureable, Achievable, Relevant, Timely).

Time Frame: Approximately 1 hour.

Materials List

- SMART GOAL Worksheet (see examples on website).

Things to Do before Activity:

- Prepare SMART Goal Worksheet

Activity Details:

Discussion Points:

- Importance of macro-nutrients and mathematical formulas to determine individual needs
- Serving size versus portion size
- SMART Goals
- Benefits of good nutrition
- Benefits of daily exercise

Things to Do during the Activity:

1. Specific Nutritional Needs: The activity starts out with students going to the following website: http://www.freeedieting.com. They can use this website to calculate their individual nutritional needs.
2. Compare: Once students have calculated their nutritional needs, they will look at their food/activity logs and compare their progress to the recommended numbers.
3. SMART Goal: Each student receives a SMART Goal worksheet and they write their goal based on the information they have found to make healthy changes to their present eating habits.

Conclusion of Activity: Students conclude the activity discussing their SMART goals.

Activity 5: Nutritional Information

Overview of Activity: This is a joint activity at the CTE school. Students from the CTE school will be helping the middle school students with reading nutritional food labels.

Time Frame: Approximately 1 hour. Not including transportation of the middle school students to the CTE.

Materials List:

- Nutritious Menu Options
- Food Label Worksheet

Things to Do before Activity:

- Prepare Nutritious Menu Options Worksheet (Note: The teachers in this project used a worksheet from the *Culinary Essential Lab Manual* (Lab Activity 40) © Glencoe/McGraw-Hill.)
  The information on the sheet includes 5 nutritional categories: proteins, carbohydrates, fats, Vitamins A, D, E, and K, Vitamins B and C. For each category students will write down two food sources containing the associated nutrient(s).
- Prepare Food Label Worksheet (Note: The teachers in this project used a worksheet from the *Culinary Essential Lab Manual* (Lab Activity 39) © Glencoe/McGraw-Hill.)
  The information on the sheet includes examples of two food labels, one for a reduced-fat product and one for a non-fat product. There are questions asking students to find the differences between the two products and to comment on why they think it is important to read and understand food labels.

Activity Details:

Discussion Points:

- Finding nutritional information for a specific food
- Important nutrients : proteins, carbohydrates, fats, Vitamins A, D, E, K, B and C.
- Ratios of nutrients to total calories (i.e., fat to total calories)
- Healthy substitutions
- Reading nutritional labels for food products

Things to Do during the Activity:

1. Food Logs: The activity starts out with middle school students sharing their food logs with CTE students.

2. Finding Nutritional Information: The middle school students will each select a food they plan to eat. CTE students will help the middle school students find nutritional information on the food choice and look at the ratios of nutrients to total calories. Students will work together to find a healthier version of the selected foods.

3. Pizza Toppings: Students from both schools will look at nutrition values for pizza toppings. They will need this for the next activity.

4. Discuss: Students discuss their ideas about childhood obesity and generate ideas about how to gather information for the project.

Conclusion of Activity: Students conclude the activity after the childhood obesity discussion.

Activity 6: Making Healthy Pizza Choices

Overview of Activity: This activity takes place at the CTE school involving both the middle school and CTE students. Each will be making their own pizza and will need to decide what ingredients they wish to have on it. Ingredients will be measured and recorded so students can determine the nutritional breakdown of their pizzas. The goal is that students will have used what they've learned over the course of this project to make healthy choices.

This activity assumes access to enough oven space to make pizzas for students at both schools.

Time Frame: Approximately 3 hours. Not including transportation of the middle school students to the CTE.

Materials List:

- A variety of pizza toppings (suggested toppings: tomato sauce, cheese, onions, peppers, broccoli, hamburger, bacon, pepperoni)
- Pizza dough
- Food scales
- Measuring devices (measuring cups, spoons, etc.)
- Nutritional Comparison Worksheet
- Post Test

Things to Do before Activity:

- Prepare or purchase enough pizza dough and toppings for students at both schools.
- Prepare Nutritional Comparison Worksheet (see examples on website).

  Suggested information to include on the worksheet:
  - Side One: For each of the pizza topping ingredients, space to record the following: calories, carbs, fat, protein, sodium, fiber. There should be space for students to answer the following question: What percent of the total calories were the carbs, fat, protein and fiber?
  - Side Two: This side shows a table that is used to compare the pizza toppings chosen by students versus a typical pizza. The comparison is made on number of calories. Following the comparison, there should be space to answer three questions:
    i. Please tell how your pizza tasted.
    ii. What did you learn about making small changes to a favorite food? Do you think you could make these changes to other foods as well?
    iii. How can these small changes have an impact on your health?
- Prepare Post Test using the same questions as in the Pre Test.

Activity Details:

Discussion Points:

- Making healthy choices in pizza toppings
- Weighing toppings to determine nutritional values

Things to Do during Activity:

1. Choices: This activity starts with students using the information they've learned over the course of this project to make healthy pizza toppings selections.
2. Weighing ingredients: The CTE students will work with small groups of middle school students to help them weigh the topping ingredients they've selected for their pizzas. This information will be recorded on the Nutritional Comparison worksheet.
3. Tallying nutritional information: Students will gather nutritional information on their pizza topping selections and make a final tally of the results. This will also be recorded on the Nutritional Comparison worksheet.
4. Taste Test!: Students make their pizzas and bake them. They get to enjoy their selection and will write a brief review of their pizza.
5. Tour of CTE school. The middle school students are given a tour of the entire CTE facility to give them a chance to see what opportunities they may want to explore as part of their high school curriculum.

Conclusion of Activity: The middle school students return to their classroom and complete the Nutritional Worksheet by comparing their pizza to a less healthy version. They will also take their post test for the project.

Reflections:

Reflections from Sue Watts, 7th Grade mathematics teacher, Thomaston Grammar School, Thomaston, ME:

1. How did this group come with the idea for this project?

   I had done this with my class without the tie in with MCST (Mid-Coast School of Technology). I really felt the kids needed to see the connection that math has with their lives. In other words, I wanted math to be real for them.

2. What worked best about the project?

   Carol was easy to work with. We both had similar goals that made it easier. It was great bouncing ideas off each other.

3. What didn't work quite so well?

   I think it all went pretty well. I would like to have seen more ways to show our data. It was mostly ratios. At the end of the year we both had commitment that made it difficult to meet to prepare for the final presentation.

4. What did students enjoy most?

   Definitely going over to the MCST to make the pizzas.

5. Would you encourage others to try this same project and why?

   Definitely. It made an impact on some of the kids in my class. I saw healthier snacks, more activity at recess, and kids talking about nutrition without my asking questions. They loved the daily exercise; it helped those kids with ADHD focus more. They saw how math really was interwoven in their lives.

6. Anything else you'd like to say about the project??

   Each year I have done this, the kids want to continue exercising and talking about healthy eating. They also look for math in every day topics. They become more aware of how to interpret data they find in articles.

Resources/References

1. Extensive material relating to goals, objectives, lessons, activities and other supporting documents were provided by the two instructors who developed this project: Carol Pelletier Mid Coast School of Technology, Rockland ME and Sue Watts, Thomaston Grammar School, Thomaston ME.
2. http://www.eduplace.com/graphicorganizer/pdf/kwl.pdf for an example of a KWL chart
3. http://olc.spsd.sk.ca/de/PD/coop/page4.html information on the jigsaw method of cooperative learning.
4. http://healthyamericans.org/reports/obesity2010/release.php?stateid=ME Article titled: *New Report: Maine Ranks 29th Most Obese State in the Nation*.
5. www.cdc.gov/healthyyouth Report titled: *The Obesity Epidemic and Maine Students*. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion and the Division of Adolescent and School Health.
6. http://new.bangordailynews.com/2010/04/02/news/bangor/battling-childhood-obesity-in-maine/print/ Article by Meg Haskell at the Bangor Daily News titled: *Beating Childhood Obesity in Maine*.
7. http://www.sportfit.com/sportfitglossary/energetics_aerobic_krvnn.html This is just one of many sites that explains the Karvonen Formula. This site shows basic version of the formula that assumes maximum heart rate is "220 – age". This alleviates the need to do a table look up for this value.
8. http://www.freeedieting.com This website is used in activity 4. It provides the calculations to determine specific nutritional needs.
9. http://www.calorieking.com/ This site provides the ability to track daily nutrients and calories as in Activity 2.
10. http://www.eduhound.com/site_sets/SMART_Goals.cfm A source for information on SMART goals, how to set them and a template.
11. Culinary Essential Lab Manual© McGraw-Hill: This is the resource for worksheets used in Activity 5.

Examples and additional materials mentioned in this project can be found at: http://mmsa.org/highlights/learn-m4cte-project-guides

Measurement and Coordinate Designs

By Irene Haskins, edited by Jessica McGreevy

Project Developers:

- Ed Lee, Welding Instructor, Mid-Coast School of Technology, Rockland ME
- Ainslee Riley, Mathematics Teacher, Oceanside West High School, Thomaston ME

This project provides a fun and tangible way to use ordered pairs in the coordinate plane to model a real life application. Students will create pictures that will be transferred to sheet metal plates using a plasma cutter!

Preface

Plasma cutters are used in manufacturing to provide clean and accurate cuts into sheet metal. This project leverages a plasma cutter to show students how mathematics has strong ties to the manufacturing world. Students will put into practice the math used in measurement, graphs and ordered pairs to transfer their own artistic designs into metal.

Why Do This Project?

In the classroom, teachers talk about the importance of measurement accuracy, but that message may not come to life for students until it is used in a real world application. This project gives the opportunity for students to see that importance.

Students will create a design of their choice and will translate the design into a set of ordered pairs. For this particular project, the students created an ocean-themed logo. They will then need to put together a set of instructions based on the ordered pairs. Before the instructions are fed into the plasma cutter, the students will use OmniGraph Sketcher to check the accuracy of their coordinates. This will allow students to see first-hand that measurement accuracy counts, because any mistakes will translate into readily apparent errors in their design.

This project was developed as a collaboration between a "regular"[3] 8th grade mathematics teacher and a welding instructor teacher at a Career Technical Education (CTE) school.

This project provides an interesting, challenging and interactive way to support the following standards:

[3] The term "regular" high school is meant to distinguish a traditional high school from a Career Technical Education high school. The same term will be used for students attending these schools. There is not an easy way to identify those students from the CTE students, so the word "regular" will be used for clarity.

Common Core State Standards for Mathematical Practice:

- *CCSS.Math.SMP.1 – Make sense of problems and persevere in solving them*
- *CCSS.Math.SMP.4 – Model with mathematics*
- *CCSS.Math.SMP.5 – Use appropriate tools strategically*

Common Core State Standards- Mathematics:

- *CCSS.Math.6.NS.8- Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.*

Overview of the Project

In this project, students create a logo design that will be cut into a piece of sheet metal using a plasma cutter. A plasma cutter works by super heating a gas to a plasma state. The designs are "cut" into the sheet metal by melting it. This process provides a very clean and accurate cut.

For this particular project, the teachers had the students develop designs that reflected the coastal Maine area in which they lived. Each of the designs was cut into an 8 by 8 inch sheet metal plate and the plates were ultimately made into a 3-dimensional sculpture. Most designs will work well, but students need to keep in mind how the plasma cutter works. If a design incorporates the outline of a shape, then a few judiciously selected segments of the outline need to be left blank. Otherwise the result would be a hole in the shape of the outline.

Once the designs are determined, students need to identify which points on the drawing are critical to the design in terms of the plasma cuttter. For example, a straight line only needs to have the two end points identified. The design drawing will be laid over the first quadrant of the coordinate plane and the distance of each of the critical points will be carefully measured on the x-axis and y-axis. Measurements are made in inches to the nearest sixteenth. Each point is then assigned an ordered pair reflecting the location of the point.

What Will the Students Learn?

- How to work with rational numbers by expressing fractions as decimal equivalents.
- How to use a ruler to measure accurately to the nearest sixteenth of an inch, in a reduced form.
- How to explain the difference between precision and accuracy.
- How to express answers to a reasonable degree of precision.
- How to use measurement to determine ordered pairs for points in the coordinate plane.
- How to determine horizontal and vertical distance in the coordinate plane.
- How to describe position and direction in two dimensions.
- How to use technology to check accuracy of measurement.
- How to use technology to replicate a drawing by using ordered pairs.

Where's the Math?

There is math throughout this project! There is graphing, measurement, geometry and ordered pairs; all the mathematics requires precision and attention to detail for students to be successful.

The Benefits of Collaboration

This project was developed as a collaboration between a mathematics teacher from Oceanside West High School in Thomaston and a Welding instructor from Mid-Coast School of Technology, Rockland, Maine. This pairing was key to the development and success of the project. Their preparation and coordination brought this project to fruition.

The students from Oceanside made the designs for the sheet metal, while the Mid-Coast School of Technology students assisted with the finishing of the sheet metal plates. Additionally, the students at the Mid-Coast School of Technology incorporated the metal plates into a three dimensional sculpture using specifications defined by the Oceanside students. The CTE school was essential in providing the equipment needed for this project, namely a PlasmaCam™ plasma cutter and supplying the facilities to professionally finish the sheet metal plates.

Toolkit – Everything You Need to Do This Project

This section describes three suggested activities for this project. For each activity there is an overview, time line, materials list, and lists of what needs to be done and discussed throughout the activity. Supporting materials can be found in the Resources/References section of this paper.

This is an example of what the teachers who developed this project put together for their students. Any CTE and math teacher team could easily adapt this project to fit their specific needs.

Access to a Plasma cutter and a computer program that can graph ordered pairs, for example OmniGraphSketcher, is necessary to make this project work.

Activity 1: Pre-test and Measuring Practice

Overview of Activity: This project takes place at the high school. Students will be introduced to the project and will learn about measurement.

Time Frame: Estimated time frame is two hours.

Materials List

- Rulers that can measure to the sixteenth of an inch
- Tape measures
- Pre- and Post-test
- Pieces of pre-cut aluminum to measure for practice
- Measurement Practice Sheet (students must accurately measure various lengths to the nearest sixteenth of an inch)

Things to Do before Activity:

- Prepare activity pre-test and post-tests (Given 4 different lines, students must measure the length of each to the nearest sixteenth of an inch). Note: Use the same problems for both tests.
- Prepare Measurement Practice Sheet (students must accurately measure various length lines to the nearest sixteenth of an inch)
- On-line ruler game website for the activity
- Have students take measurement Pre-Test
- Pre-cut several pieces of aluminum for measurement and measure them in order to have a key.

Activity Details:

Discussion Points:

- How to take measurements
- How a ruler is broken down
- How final group measurements were determined
- What is the difference between precision versus accuracy
- What discrepancies can result from using different rulers
- How to measure when the ruler does not begin with zero
- How to use a tape measure

Things to Do during the Activity:

Note: The first two steps can be done before the activity in individual classrooms.

1. Ruler Game: Use the Ruler Game website to practice measuring to the nearest sixteenth of an inch.

2. Practice Measurement: Students complete worksheets to practice measuring to the nearest sixteenth of an inch. Students first work as individuals and then compare answers to come up with a group answer sheet. (Optional, time permitting: Have students practice measuring when the ruler does not start at zero.)

3. Measuring objects: Students work individually to complete measurements of various pre-cut aluminum objects to the nearest sixteenth of an inch. They then compare answers to come up with a group answer sheet. They will use both rulers and tape measures.

4. Final Group Measurements: Discuss final measurements, correct group sheets, and determine winning group.

Conclusion of Activity: Students take a post-test for activity (the same as the pre-test).

Activity 2: Practice Drawings

Overview of Activity: This activity addresses background information and design considerations the students will need to make in order to have a plasma cutter cut their designs into sheet metal. The plasma cutter will need to "know" what the design looks like. The students provide that knowledge via a set of ordered pairs. They will need to determine which points in a drawing need to be identified for the plasma cutter. For example, only the two end points of a line would need to be identified. Additionally, for metal cuts, there is a constraint to leave "gaps" in a line. Otherwise the plasma cutter will cut out only the outline of a shape and the entire interior would be gone. The students will also need to determine the order of the coordinate points. This is important so the plasma cutter will know the path to make the cuts in the metal. The order of the cuts is essential to achieve the intended design.

One way to check a design prior to cutting a design with the plasma cutter is to use a computer program such as OmniGraphSketcher. Once the set of coordinates and their order is determined, they can be entered into the program. Instead of making metal cuts, it will produce a visual representation. This will help students to identify mistakes in coordinate pairs and/or the ordering of the points.

Time Frame: This activity is estimated to take 2 hours.

Materials List:

- Activity Pre- and Post-tests
- Worksheet of pre-drawn shapes.
- OmniGraphSketcher software on a Mac computer

Things to Do before Activity:

- Prepare activity pre and post-tests (Given a coordinate plane with 5 points, identify the ordered pairs associated with each point).
- The CTE teacher covers the coordinate information separately with his class.
- Prepare worksheets of pre-drawn shapes.

Activity Details:

Discussion Points:

- Determining coordinates to the sixteenth of an inch
- How to use OmniGraphSketcher
- Determining which points in a design are critical to the design and need to be identified for the OmniGraphSketcher application
- Determining the order of the coordinate pairs and why this is important
- Drawing constraints for metal cut designs

Things to Do during the Activity:

Note: For this activity 8th grade students met at the CTE.

1. Pre-Test for Activity: Students will take a pre-test in which they are asked to determine critical point coordinates for a drawing.

2. Ordered Pairs to the Nearest Sixteenth of an Inch. The CTE teacher will introduce the students to coordinate pairs and how to determine them to the nearest sixteenth of an inch. Fractions will need to be converted to decimals to the nearest ten thousandth.

3. OmniGraphSketcher: The CTE teacher will introduce students to OmniGraphSketcher.

4. Finding Coordinates: Students will work individually to identify critical point coordinates of pre-drawn shapes. They will also need to determine the order the coordinate points need to be entered into OmniGraphSketcher. Teachers will circulate to help students

5. Checking Coordinate Points: Students will type the coordinates into OmniGraphSketcher to check their accuracy, determine errors made, if any, and make corrections for those errors

6. Design Constraints: Teachers will go over design constraints with students for their drawings. Students will need to keep in mind how the plasma cutter will create their designs. If a design incorporates the outline of a shape, then a few judiciously selected segments of the outline need to be left blank.

Conclusion of Activity: Students are given a Post-Test (the same as the Pre-Test) in which they are asked to determine coordinates for a drawing

Activity 3: Metal Plate Designs

Overview of activity: In this activity, regular high school students will create and test the designs to be cut by the plasma cutter.

Time Frame: 2 hours

Materials List:

- Paper for 8”x8” drawings
- OmniGraphSketcher or similar computer program

Things to do before activity:

- Arrange to have an art teacher join the event for guidance on drawing designs (optional).

Activity Details:

Discussion Points:

- Review design constraints

Things to do during activity:

1. Create Design: Each student will create an original 8” x 8” drawing (with assistance from the art teacher). They will need to make sure that their design meets the given constraints and determine coordinates for that drawing to the nearest sixteenth of an inch. They will convert their fractions to decimals to the nearest ten thousandth.
2. Coordinate List: Students will need to produce a coordinate cut list for their drawing. This list contains the critical coordinate points needed by the plasma cutter and the order in which the plasma cutter needs to travel to the coordinate points.
3. Check Coordinate List with OmniGraphSketcher: Students will use OmniGraphSketcher to determine whether or not their coordinates are accurate. If the drawing OmniGraphSketcher produces does not depict what is shown in the student’s drawing, they will determine where errors were made and correct those errors.

Conclusion of Activity: Submit drawings and coordinate cut list: Once OmniGraphSketcher shows a drawing that reflects the drawing the student created, they will need to submit the coordinate list and a copy of their drawing to their teachers.

Note: If there are anticipated time constraints to create a metal plate for each student, the students can pick a subset of the drawing to be created.

Activity 4: Final Project – Creation of Metal Plate Designs

Students with completed metal plates.

Overview of activity: This is the final activity for the project. Prior to meeting, 8th grade students voted on their 12 favorite designs. The students who created the chosen designs meet at the CTE for the creation of the metal plates.

Time Frame:

Materials List:

- Plasma cutter
- 8"x8" metal plates

Things to Do before Activity:

- The CTE teacher and students enter the coordinate cut lists into the plasma cutter.

Activity Details: 3 to 4 hours, not including transportation

Discussion Points:

- Provide a demo of the plasma cutter, how it works, safety features, etc.

Things to Do during the Activity:

1. Plasma cutter: Students observe the plasma cutter cutting the sheet metal plates.

2. Finishing the plates: The CTE students will complete finishing work on the sheet metal plates (e.g., polishing the plates).

3. Discuss: After all the plates are cut, conduct a discussion about anything that went wrong. Talk about what should have happened.

Conclusion of Activity:

- After completion of the Pre- and Post-Tests, results will be shared with the students and correct answers will be discussed.

- Students will be asked to complete a written debrief in which they reflect about what they did wrong, if anything, and what they learned. This debrief will be the focus of a group discussion.

Reflections by Ainslee Riley and Ed Lee:

"Next time we would start the project with the students earlier in the year, spread the lessons out and give more time for students to measure and coordinates during class time. We would also want to avoid scheduling it during other major school project because it is so time-intensive."

Resources/References

1. Much of the information for this document is based on documentation provided by the two instructors who developed this project: Ed Lee of the Mid-Coast School of Technology, Rockland, ME and Ainslee Riley of Oceanside West High School (West) in Thomaston, ME

2. http://www.omnigroup.com/products/omnigraphsketcher/support/ - information on OmniGraphSketcher application.

3. http://home.howstuffworks.com/plasma-cutter1.htm - the website provides a good introduction to plasma cutters.

Examples and additional materials mentioned in this project can be found at: http://mmsa.org/highlights/learn-m4cte-project-guides

Pendulum Palooza

Written by Sara Gilfenbaum, edited by Irene Haskins and Jessica McGreevy

Project Developers:

- Sara Gilfenbaum, Sixth Grade Teacher, Thomaston Grammar School, Thomaston ME
- Clare Stinson, Introduction to Applied Technology Instructor, Mid-Coast School of Technology, Rockland ME
- Gretchen Tripp, Sixth Grade Teacher, Rockland Middle School, Rockland ME

Conducting experiments with pendulums, collecting and analyzing data are the keys to this project designed to increase students' mathematics vocabulary and introduce Measures of Central Tendency through Scientific Inquiry.

Preface

In this project, the Scientific Inquiry Method is leveraged to help students get a better grasp on the importance of analyzing data. This allows students to better comprehend the definitions of mean, median, mode and range. Creating a graph and using triple entry journals for each vocabulary word will also reinforce these definitions.

Pendulums and an online stop watch program are used to help create a high level of engagement. The activities will help students firmly embed the information and give them a reference point for future learning.

Why Do This Project?

Math vocabulary is often difficult for middle school students to grasp. Actively collecting and analyzing data is not only more engaging, but offers a firm basis for *understanding* the material. Being able to manipulate vocabulary demonstrates a clear understanding of information.

This project was developed as a collaboration between two 6th grade teachers and an applied technology teacher at a Career Technical Education (CTE) school.

This project is interactive, exciting and provides strong connections to the following Common Core State Standards Practices (CCSS):

Common Core State Standards for Mathematical Practice:

- *CCSS.Math.SMP.1- Make Sense of Problems and Persevere in Solving Them*
- *CCSS.Math.SMP.3 – Construct Viable arguments and critique the reasoning of others.*
- *CCSS.Math.SMP.4 – Model with Mathematics*
- *CCSS.Math.SMP.7 – Look for and make use of structure.*

Common Core State Standards- Mathematics:

- *CCSS.Math.6.SP.A – Develop understanding of statistical variability.*
- *CCSS.Math.6.SP.B – Summarize and describe distributions.*

Overview of the Project

Middle school students set up and conduct three experiments involving table-top pendulums. The variables for these experiments are length of string, weight of the bob and angle of release. Students will predict how the frequency of the pendulum will be affected based on changes to the variables. Data is collected on a lab sheet and then analyzed to find the mean, median, mode and range. Following this analysis, students create a graph and report out findings to their classmates.

A subsequent activity involves the middle school students traveling to the local CTE where they conduct the same experiments using a giant pendulum. The same process of using prediction, data collection, graphing, and reporting out is also applied to the giant pendulum. Additionally, students compare the results of the giant pendulum with the smaller tabletop pendulum. Did they achieve the same results? How does pendulum size affect the experiment?

What Will Students Learn?

- *The Scientific Inquiry Method and how to apply it*
- *Mathematical vocabulary*
- *How to plan and conduct a fair experiment*
- *How to collect and summarize numerical data*
- *How to make predictions (i.e., statistical inferences)*
- *How to analyze data and find mean, median, mode and range*
- *How to present findings in a graph and communicate the results*
- *How to model a real life situation with mathematics*
- *How to create a tabletop pendulum (if the students will be doing this as part of the project)*
- *How to make predictions about the impact of changing variables in an experiment*
- *How to calculate, analyze and graphically display the mean, median, mode and range of a data set*
- *How to compare predictions to the actual outcome*

Where's the Math?

In this project, students will collect and summarize numerical data using descriptive statistics (graphing, measures of central tendency and spread). They will use their data to make statistical inferences. Strong focus is put on data collection and building mathematical vocabulary.

The Benefits of Collaboration for This Project

Two 6th grade teachers and a technology teacher developed this project. Some teacher reflections are below.

Sara Gilfenbaum's reflections:

The project was developed for three reasons.

1. The two middle schools were part of a new RSU (Regional School Unit). The middle school teachers felt it was important for students at both their schools to come together as a transitional activity.
2. The activity utilizes the prior knowledge of the participants and allows them to engage in an active, hand-on activity.
3. In partnering with the CTE School, middle school students were introduced to the possibility of an alternate route to their education.

Teacher Q&A:

1. What do you think the benefits of setting up collaborations between high schools/middle schools and the CTE?
   Middle school students can be difficult to excite. This collaboration opened up the possibilities for students that they previously did not realize existed.

2. What worked really well about the collaboration?
   Clare Stinson, our CTE teacher was wonderful to work with. The tour of the (CTE) school was also a highlight.

3. What didn't work quite so well about the collaboration?
   Because Clare teaches freshman, he felt that it would be easier if his students were not involved. In the future I think it would be helpful to find a place for them in this project.

4. What would change if you were to do this again?
   The involvement of the CTE students would be beneficial.

5. In particular, how did students from both schools benefit?
   It was enlightening for the sixth grade because they understand the different options for their high school experience.

Toolkit – Everything You Need to Do This Project

This section details five suggested activities for this project. This is an example of what the teachers who developed this project put together for their students. Any CTE and middle school math teacher team to fit their specific needs could easily adapt this project.

Most of the activities take place in the individual classrooms at the middle schools. There is one joint activity for both middle schools at the CTE school. Support information can be found in the Resources/References section of this paper.

Activity 1: Intro to Pendulum Palooza

Overview of Activity: In this activity, students take a pre-test for the project. They will take the same test at the end of the project.

Time Frame: Part of a class period

Materials List:

- Pre-Test

Things to Do before Activity:

- Prepare Pre-test: (see example on website)

Activity Details:

Discussion Points: None since only the pre-test is being done.

Things to Do during the Activity:

1. Pre-test: Pass out the pre-test and have students answer the questions.

Conclusion of Activity: This activity concludes with completion of the pre-test.

Activity 2: Triple Entry Journal

Overview of Activity: Triple Entry Journal

Time Frame: Part of a class period - can be combined with the pre-test

Materials List:

- Triple Entry Worksheet (one per student)

Things to Do before the Activity:

- Prepare Triple Entry Worksheet. (see example on website)

Activity Details:

Discussion Points:

- What is Triple Entry Journal?
- Mean
- Median
- Mode
- Range

Things to Do during Activity:

1. Journal Entry: Students create their journal entry for each of the terms listed on the worksheet. This becomes part of their learning for this activity, as well as other activities in the project.

Conclusion of activity: Activity concludes with students completing their journal entry.

Activity 3: Pre-Teach Graphing

Overview of Activity: This activity introduces students to various graphical displays of data.

Time Frame: As many classes as needed, depending on student needs

Materials List:

There are many sources available for teaching how to graphically display data. A good source is: http://illuminations.nctm.org

The following is a suggested collection of lessons from the website above that teach various ways to represent data.

- Representing data, creating graphs and rules from an organized chart
- There is a Difference: Histograms vs. Bar Graphs
- Using NBA statistics for Box and Whisker Plots
- Summer Daze (Pie Charts)
- Information Represented Graphically

Things to Do before Activity:

- Explore graphing resources and determine which to use based on class needs.
- Prepare worksheets as appropriate.

Activity Details:

Discussion Points:

- Representing data
- Data tables/charts
- Histograms and bar graphs
- Pie charts
- Box and whisker plots

Things to Do during Activity: This will vary depending on class needs.

Conclusion of Activity: This will vary depending on class needs.

Activity 4: Experimenting with Tabletop Pendulums

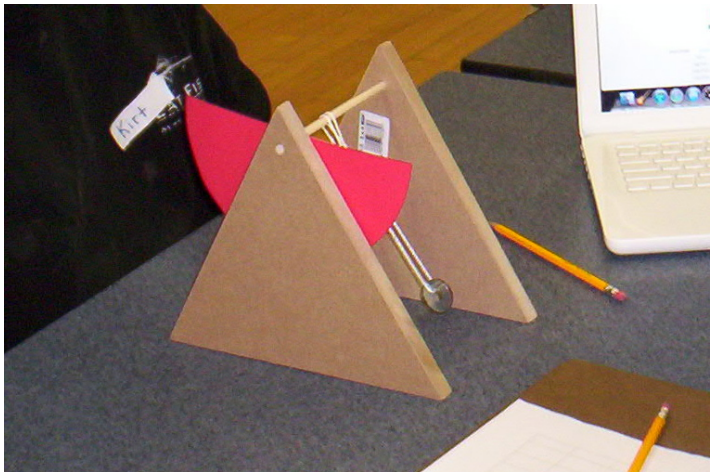
Overview of Activity: This activity involves experimenting with tabletop pendulums. Construction of the pendulums is not part of this project, but could be easily added. Students will be testing the frequency of their pendulums and how it changes based on angle of release, length of string and mass of the pendulum weight.

Time Frame: At least two class periods.

Materials List:

- Tabletop Pendulums (see photo below)
- Computer for on-line stop watch application: http://www.online-stopwatch.com/
- Lab sheets
- Large paper for graphing
- Markers/rulers

This is a picture of the tabletop pendulum. The triangles are approximately 6-inch equilateral triangles. A hole was drilled for the dowel and the weights were regular washers. A paper protractor was created to measure the angle of release. There are some suggested web pages in the Resources/References section that give examples.



Things to Do before Activity:

- Prepare the lab sheets. Tables are needed to record frequency of the pendulum for changes in angle of release, string length and pendulum weight (see example on website).

Activity Details:

Discussion Points:

- Explain what is meant by keeping a variable "constant" (unchanged)
- Explain how to record on the lab sheets
- Talk about how to make predictions
- Explain how Onlinestopwatch.com works
- Explain how to calculate frequency of pendulum by counting number of swings in a given time period

Things to Do during Activity:

1. Groups: Break students into groups. Each group of students will complete one of the experiments (angle of release or weight or length of string) listed below. For each experiment, students concentrate on answering the question shown.

   Experiment 1: Angle of release

   Experiment 2: Mass of pendulum weight

   Experiment 3: Length of string

   In each experiment students will be asking one of the following questions:

   - *How does the starting angle (angle of release) affect the frequency of the pendulum?*
   - *How does mass of the pendulum weight affect the frequency of the pendulum?*
   - *How does length of string affect the frequency of the pendulum?*

   Test only one variable at a time with the remaining two variables being held constant. Note: In order to make the experiment a fair test, the following control constraints are recommended:

   - Angle of Release - 60 degrees
   - Weight -5 bobs, (5 washers)
   - Length of string – 12 inches

2. Experiment, predict and record: Each group will record the frequency of their pendulum. The number of pendulum swings in 15 seconds determines frequency. Students will be asked to predict how the frequency of the pendulum is affected by the variable being tested.
3. Summarize data: After completing the appropriate lab sheet, each group will calculate the mean, median, mode and range of their data.
4. Graphical Display: Each group will decide the best way to graphically display their data. They will make graphs on the large paper.
5. Present: Each group will report out their findings by explaining the graph(s) they have created.

Conclusion of Activity: This project wraps up with a discussion about the experiments and the results found. Students will use a gigantic pendulum in their next activity and be asked, based on what they learned so far, how the gigantic pendulum frequency will be affected by the same variables.

Activity 5: Experiment with Humungous Pendulum (Optional, if access to a gigantic pendulum is available)

Overview of Activity: In this activity, middle school students will conduct their pendulum experiments on a humungous pendulum. For the teachers who developed this project, this activity took place at CTE school using a giant pendulum constructed by the CTE teacher. The humungous pendulum adds a "Wow factor" for students and reinforces what they learned in Activity 4. It also allows them to use what they learned from the tabletop pendulums to make inferences about the humungous pendulums.

The same angles of release can be tested with a constant string length of 12 feet and mass of 30 pounds for the weight. For testing the impact of weight masses, it is suggested to use weights of 30, 45 and 60 lbs. The constants would be length of rope 12 ft. and 30 degrees.

Note: It is important to refer back to the tabletop experiment. It is also important to check predictions that students made against their results.

Time Frame: 2 hours, not including transportation time to the CTE.

Material List:

- Humungous pendulum (see photo)
- Lab sheets to record findings

Things to Do before Activity:

- Revise the lab sheets to reflect the variables being tested: length of rope, angle of release and the weight (see Activity 4 for examples of lab sheets).

Activity Details:

Discussion Points:

- Review results of tabletop experiment
- Making predictions from previous results

Things to Do during Activity:

Note: These instructions are written in terms of three groups of students each testing one variable (i.e., angle of release, mass of pendulum weight and length of rope). The experiment can be done as an entire group if not all 3 variables are to be tested.

1. Groups: Break students into groups. Each group of students will complete one of the experiments.

   Experiment 1: Angle of release

   Experiment 2: Mass of pendulum weight

   Experiment 3: Length of rope

   In each experiment students will be asking one of the following questions:

   - *How does the starting angle (angle of release) affect the frequency of the pendulum?*
   - *How does mass of the pendulum weight affect the frequency of the pendulum?*
   - *How does length of rope affect the frequency of the pendulum?*

2. Experiment, predict and record: Each group will record the frequency of their pendulum relative to the variable being tested. Frequency is determined by the number of pendulum swings in 15 seconds. Students will be asked to predict how the frequency of the pendulum is affected by the variable being tested.

3. Summarize data: After completing the appropriate lab sheet, each group will calculate the mean, median, mode and range of their data.

4. Graphical Display: Each group will decide the best way to graphically display their data. They will make graphs on the large paper.

5. Present: Each group will report out their findings by explaining the graph(s) they created.

Conclusion of Activity: This project wraps up with a discussion about the experiments and the results found. Students take the post-test for this project.

Reflections/Suggestions

Reflections from the three teachers who developed this project:

1. How did this group come with the idea for this project?

   Sara and Gretchen both teach sixth grade. Although they both cover the same areas in math, their curriculums are different. Because measurement is a focus of this project, it seemed that a data collection activity would benefit both classes. Clare initiated working with Sara and Gretchen because his students also work with data. Developing an experiment to collect data seemed the most engaging. After discussing several ideas we decided on using pendulums.

2. What worked best about the project?

   Students were engaged, focused and productive throughout this project. Having both groups of sixth graders come together was an excellent idea. The structure of the experiment days at both Thomaston Grammar School and Mid-Coast School of Technology was flawless.

3. What improvements would you suggest?

   We need to be more specific about the graphing process and perhaps should develop a lesson around this. We need to be more specific about the presentation of the outcomes. A rubric given to students before would be beneficial. Connecting the predictions to the actual outcome should be discussed more. Connecting the results of the tabletop pendulums to the large pendulum should be discussed in more detail.

4. What did students enjoy most?

   They loved the day of the experiment. It was so novel, unlike most school days. They also thought the large pendulum was amazing and were completely sold on the possibility of attending a CTE school.

5. Would you encourage others to try this same project and why?

   Yes. Most students complain that math is not relevant to their everyday life. By developing and conducting an experiment it becomes easier to see the connections.

Suggestions from the Teachers:

1. *Pre-teach graphing. This is included as an activity.*
2. *Develop rubric for communicating experiment results.*
3. *Allow time to make a connection between prediction and results for both the small and large pendulums.*
4. *Create a rigorous pre and posttest.*

Resources/References

1. Material relating to goals, objective and other supporting information was provided by the three instructors who developed this project: Sara Gilfenbaum (Thomaston Grammar School, Thomaston ME) , Gretchen Tripp (Rockland Middle School, Rockland ME) and Clare Stinson (Mid-Coast School of Technology). Special thanks to Sara Gilfenbaum who wrote this Project Guide.

2. http://www.experiment-resources.com/pendulum-experiment.html

3. http://www.worsleyschool.net/science/files/pendulum/pendulum1.html

4. http://www.experiment-resources.com/pendulum-experiment.html

5. http://www.wikihow.com/Build-and-Use-a-Pendulum

6. Rubric for student presentations: Created for the Fermilab LInC program sponsored by Fermi National Accelerator Laboratory Education Office and Friends of Fermilab, and funded by United States Department of Energy, Illinois State Board of Education, North Central Regional Technology in Education Consortium which is operated by North Central Regional Educational Laboratory (NCREL), and the National Science Foundation.

   Author(s): Ronda Larson-Dranter, Mary A.Warren
   School: Old Quarry Middle School, Lemont, IL (http://www.sd113.s-cook.k12.il.us/oq/oqindex.html)
   Created: March 12 - Updated: March 13, 2001
   URL: http://www-ed.fnal.gov/lincon/w01/projects/library/presrubric.html

7. http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml Information on the scientific inquiry method.

Examples and additional materials mentioned in this project can be found at: http://mmsa.org/highlights/learn-m4cte-project-guides

Ramp It Up!

By Stacy LaBree, edited by Irene Haskins and Jessica McGreevy

Project Developers:

- Cynthia Blanchard, Mathematics Teacher, Old Town High School, Old Town, ME
- Jack Ledger, Technology Teacher, Orono High School, Orono ME
- Dave Stevens, Building Construction Management Instructor, United Technologies Center, Bangor ME

Preface

Ramp It Up! is a hands-on project that integrates mathematics and building construction for students to implement a real-world and meaningful application. Students design and build a wheelchair ramp according to ADA (American Disabilities Act) specifications and guidelines in tandem with the measurements of an actual house. The ramp design must meet criteria for slope, the dimensions of the house site, and be modular so that it can be transported. This is a high interest lesson that has the potential to include a community service learning component.

Why Do This Project?

Teaching students how to apply mathematics to real life problems is an excellent method for enhancing their understanding of isolated math concepts. A Chinese Proverb states, "I hear and I forget. I see and I remember. I do and I understand." This project incorporates lots of "doing"! High school Common Core State Standards call on students to practice applying mathematical ways of thinking to real world issues and challenges. They prepare students to think and reason mathematically. This project addresses the following Common Core State Standards:

Common Core State Standards for Mathematical Practice:

- *CCSS.Math.SMP.1 - Make sense of problems and persevere in solving them.*
- *CCSS.Math.SMP.3 - Construct viable arguments and critique the reasoning of others.*
- *CCSS.Math.SMP.6 - Attend to precision.*

Common Core State Standards- Mathematics:

- *CCSS.Math.7.G.1 – Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.*
- *CCSS.Math.8.G.7- Apply the Pythagorean Theorem to determine the unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.*
- *CCSS.Math.HS.G.SRT.8 – Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.*

Overview of the Project

Ramp It Up! involves activities covering ADA Standards, ramp design, geometry, the Pythagorean theorem, and construction safety. These are conducted with the individual classrooms to provide students with background knowledge and understanding of the project. The construction of the wheelchair ramp was the culmination of these activities. Each topic was explored, discussed, and practiced by students. Students used ADA guidelines and house measurements to determine the ramp design through math concepts such as slope, trigonometry ratios and the Pythagorean theorem. The design was sketched and then Google Sketch-up software was utilized to produce an 'isometric' drawing of the ramp, illustrating it 3 dimensionally and providing necessary measurements. Students consulted the schematic to determine the materials needed for construction and devised a cost estimate of the project. An elevation diagram of the house was reviewed by students. Measuring was an integral part of the construction process. An example of tying measurement and geometry to each other occurred when students had to determine if a given section of the ramp was truly rectangular. Students measured the diagonals of the section to ensure that they were equal and bisected each other.

What Will Students Learn?

- How to apply appropriate construction standards and processes to produce a project designed to fulfill a specific need
- How to use trigonometric ratios to find unknown lengths through indirect measurement
- The importance of producing an accurate materials list and quote
- How and when to apply trigonometric ratios
- How and when to apply Pythagorean Theorem
- How to determine the level of precision necessary to build a ramp.
- How to use slope formula, slope as a ratio of rise to run, and calculate slope
- Where to find local and national building codes/design specifications
- How to interpret national design standards (such as slope of 8% or 1:12)
- How to make accurate linear and angular measurements to the appropriate level of precision
- How to develop an accurate materials list and quote
- How to read construction drawings and details
- How to cut and assemble the materials per plans as drawn
- How to create an accurate scale drawing
- How to follow appropriate safety procedures during construction

Where's The Math?
Through this project, students learn how to identify and apply trigonometric ratios. They calculate, interpret and apply slope and create real life scale drawings. In addition, they accurately make linear and angular measurements to an appropriate level of precision in order to construct a real-life object.

The Benefits of Collaboration for This Project

Ramp It Up! was developed as a collaboration between a high school mathematics teacher, a high school technology teacher and a CTE building construction management teacher. These teachers combined their expertise to create a successful project. The students from all three schools came together to build the ramp. Due to safety guidelines, only the CTE students could operate power tools, but the regular high school students were involved with all other aspects of construction.

Toolkit – Everything You Need to Do This Project

This section describes several activities for this project. Supporting materials can be found in the Resources/References section of this paper. Examples of worksheets are available via website.

This is an example of what the teachers who developed this project put together for their students. Any CTE and regular math teacher team could easily adapt the project to fit their specific needs.

Activity 1: Scaled Drawings

Overview of Activity: Students created a scale drawing of a ramp that will fit a client's home and meet ADA specifications and building code.

Time Frame: Approximately one 80-minute class or two 45-minute class periods.

Materials List:

- Graph paper
- Rulers
- ADA specification handouts

Students and teachers sitting on the wheelchair ramp prior to transport.

Things to Do before Activity:

Students should have some prerequisite knowledge over the following concepts:

- Lessons and math practice on trigonometric ratios
- Lesson on finding scale
- Lessons and math practice on calculating slope (slope formula: ratio of rise to run)
- Lesson on using the Pythagorean theorem to find the missing side in a right triangle.

Activity Details:

Discussion Points:

- Discuss what the National Design Standards 8% or 1:12 are and their implications.
- Review house site dimensions.
- Discuss ADA specifications.

Things to Do during Activity:

1. Background Information: The activity starts by covering the discussion points.
2. Scaled Drawings: Students will be given graph paper and rulers. They will apply their knowledge and understanding of slope, trigonometric ratio, and Pythagorean theorem to create their own drawing to scale of the ramp.
3. Class Scaled Drawing Project: Students discuss their drawings/findings and create a whole class scaled drawing product.

Conclusion of Activity: Students check their calculations for accuracy and ensure ADA specifications were met. Students also confirm that the scale drawing is in its final product form. This can be done as a whole class or in small groups.

Activity 2: Three-dimensional Drawings

Overview of Activity: Students will use Google Sketch-up Software to create detailed construction drawings. They will verify that the ADA regulations/specifications are met.

Time Frame: One or two 80-minute class periods, depending on students' proficiency with Google Sketch-up software.

Materials List:

- Scaled drawing of ramp from Activity 1.

Things to Do before Activity:

Students should have some prerequisite knowledge of Google Sketch-up usage.

Activity Details:

Discussion Points:

- What are 3-dimensional isometric drawings and how to use them.
- Review how to use Google Sketch-up to create construction plans.

Things to Do during Activity:

1. Isometric Drawings: Teacher and students discuss 3 dimensional isometric drawings using essential questions as "Will my drawing give enough detail to accurately reflect the appropriate level of detail?"
2. Google Sketch-up: Review Google Sketch-up
3. Create isometric drawing: Using the drawing from Activity 1, students will work in pairs or independently at a computer to create an isometric diagram of the wheelchair ramp using Google Sketch-up. Teachers will monitor students' progress.

Conclusion of Activity: The activity concludes once students have completed their plans. Student pairs are combined into groups. Each pair will present their diagram to their group. Each group will decide on one drawing and present it to the whole class. The teacher will facilitate a class vote to decide on one drawing for the final plan.

Activity 3: Materials and Cost Estimate

Overview of Activity: Students will read the construction drawings. They will extrapolate information derived from the plans to generate a materials list and project cost estimate for the client.

Time Frame: One 80-minute class period.

Materials List:

- Blueprint/3 dimensional diagram from Activity 2
- "Materials Needed" worksheet (see example on website)
- "Cost Estimate" worksheet with local pricing resources (see example on website)

Things to Do before Activity:

- Students should be taught the process of creating a materials list and cost estimate and given the opportunity to practice given various construction plans.

Activity Details:

Discussion Points:

- Discuss/review the process to devise a materials list from blueprint plans
- Review "Materials Needed" worksheet and "Cost Estimate" worksheet
- Discuss/review the local pricing resources and how to obtain them

Things to Do during Activity:

1. Accurate Materials List and Cost Estimate: The teacher will review the process of creating an accurate materials list and detailed cost estimate.
2. Extrapolate: Students will partner and then extrapolate the information to create a "Materials Needed" list and "Cost Estimate" using the worksheets as a guide and referencing local pricing resources. The teacher will check in with the student pairs to monitor their progress and provide assistance.

Conclusion of Activity: The groups share their research with the whole class and contribute to the creation of a Master "Materials Needed List" and "Cost Estimate".

Activity 4: Construction

Overview of Activity: Students construct a wheelchair ramp as a culmination of the previous lessons and activities. Students employ mathematical concepts to accurately make linear and angular measurements to an appropriate level of precision in order to construct a real-life object.

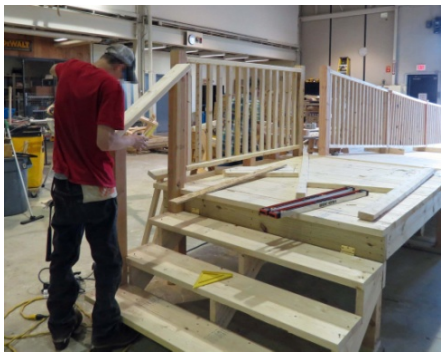
Time Frame: Approximately 4 ½ hours

Materials List:

- Materials from "Materials List" (i.e.: lumber, nails, screws, etc.)
- Power Tools (drill, saw, etc.)
- Measuring Tools (level, tape measure, square, etc.)
- Miscellaneous Tools (hammer, screwdriver, etc.)

Things to Do before Activity: Students should have some prerequisite knowledge over the following concepts:

- Construction plans.
- Various construction techniques.
- Construction safety.
- Appropriate attire: substantial footwear, long pants, no loose or baggy clothing and hair must be tied back.
- Order of construction tasks and what the tasks are:
    - Level 1 Tasks:
        - Measuring
        - Marking
        - Assembling the Ramp
        - Using Power Screwdriver (hand drill with screwdriver attachment)
    - Level 2 Tasks:
        - Cutting with Saw
        - Drilling Pilot Holes
        - Assembling the Railing



A student assembling the ramp railing.

Activity Details:

Discussion Points:

- Discuss shop safety and orientation (i.e., "How to lose your fingers")
- Give out construction assignments and groups to students

Things to Do during Activity: The ramp building will take place in the construction classroom and building area at the CTE.

1. Review Schematics: Students will be given schematics of the ramp and an elevation diagram of the house site. These will be reviewed prior to the construction.
2. Construct Ramp: CTE students will perform in the role of general contractors supporting the high school math students. Due to OSHA safety requirements, CTE students will perform the task of manning the power tools, while high school math students will be in charge of taking measurements and hammering. Students will work as a team on the construction tasks.

Conclusion of Activity: The activity is recapped by covering the learning objectives. The teacher will go over what students accomplished, discussing that the same methods used for building the wheelchair ramp are also used in the construction of houses and other large structures can follow this.

(Note: While not part of the joint construction activity, CTE students will assist in the set-up of the ramp at its final location.)

Resources/References

1. Material relating to goals, objectives, lessons and other supporting information was provided by the three instructors who developed this project: Cynthia Blanchard of Old Town High School, Jack Ledger of Orono High School and Dave Stevens of United Technologies Center.

2. Reference the following link to read the ADA specifications for ramp construction: http://www.access-board.gov/adaag/html/adaag.htm-4.8

Examples and additional materials mentioned in this project can be found at: http://mmsa.org/highlights/learn-m4cte-project-guides

Wind Turbines

By Shari Arnold, edited by Irene Haskins and Jessica McGreevy

Project Developers:

- Shari Arnold, English Teacher, Bangor Christian School
- John Milligan, Construction Engineering Technology Instructor, United Technologies Center
- Emily Spaulding, Science Teacher, Bangor Christian School

So the math teacher is busy? Here is a project teaming up a Science teacher and English teacher along with CTE Construction/Engineering instructor! (It can be adapted to include a math teacher, too!)

Preface

In this highly interactive project, field trips and activities are used to support students in the process of designing and testing their own wind turbine blade. Students summarize their results on a scientific poster.

Why Do This Project?

This project is beneficial on many levels because it combines English, Science, Math and Construction. It also opens students' eyes to the process of manufacturing wind turbines. Students work together in teams toward a common goal and end the project with a presentation.

This project supports the following Standards:

Maine Learning Results: Science and Technology:

- **Skills and Traits of Technological Design.**

  B1: Students methodically plan, conduct, analyze and communicate results of in-depth scientific investigations, including experiments guided by a testable hypothesis.

  B2: Students use a systematic process, tools and techniques, and a variety of materials to design and produce a solution or product that meets new needs or improves existing designs.

Maine Learning Results: English Language Arts:

- **Research**

  C1: Students develop research questions and modify them as necessary to elicit, present, and critique evidence from a variety of primary and secondary sources following the conventions of documentation.

- **Grammar and Usage**

  D1: Students apply rhetorical skills when reading, writing, and speaking through their understanding of Standard American English.
- **Mechanics**

  D2: Students demonstrate the use of the structures and conventions of Standard American English in their communication.
- **Speaking**

  E2: Students determine speaking strategies for formal and informal discussions, debates, or presentations appropriate to the audience and purpose.

Common Core State Standards-Mathematics: Standards for Mathematical Practice

- *CCSS.Math.Practice.MP1- Make sense of problems and persevere in solving them.*
- *CCSS.Math.Practice.MP2- Reason abstractly and quantitatively.*
- *CCSS.Math.Practice.MP3- Construct viable arguments and critique the reasoning of others.*
- *CCSS.Math.Practice.MP4- Model with mathematics.*
- *CCSS.Math.Practice.MP5- Use appropriate tools strategically*

Overview of the Project

This project takes place in a series of activities and field trips. These activities include a fun tower-building competition using marshmallows and tooth picks, English lessons focusing on documenting scientific research, construction and testing of small wind turbines and presentation of findings. Optional, but highly recommended, field trips to a wind turbine farm and to a composites lab are also described.

What Will Students Learn?

- Putting a wind turbine in place requires many steps and people
- How to work with people from different backgrounds and the importance of all to a group
- The need for exact notes when working through a process that will be repeated
- The importance of grammar skills in scientifically conveying project results
- How to make a scientific poster to meet the standards of aesthetics and function
- That recording data throughout the engineering design process is as important as the end product
- That the engineering process involves many components: design, testing, building, and marketing

Where's the Math?

This project incorporates mathematical reasoning, measurement, analyzing and summarizing quantitative data, graphically displaying data and modeling a real life situation. Additionally, students will construct viable arguments by creating and testing hypotheses.

The Benefits of Collaboration for This Project

By Shari Arnold (English Teacher, Bangor Christian School):

Students from United Technologies Center offered their expertise in the designing and building aspects of the project. This knowledge proved extreme valuable to the Bangor Christian students. The science class brought the entire idea of trial and error mixed with the scientific process. Science students were familiar with using these skills in the lab but not in the real world of construction. These same students were 'shocked' to see English class play a part in the process. The ideas of exact language, audience, sequence, correct grammar, and proof for a thesis ('hypothesis' in science-lingo) all played a part.

This collaboration took these classroom skills and brought them to life in real world situations and proved the importance of mixing ALL the things students learn together to bring about an outcome that all could be proud of, their scientific poster.

Toolkit – Everything You Need to Do This Project

This section describes four activities for this project. There are two suggested field trips and these are described separately in the document. Supporting materials can be found in the Resources/References section of this paper.

This is an example of what the teachers who developed this project put together for their students. Any CTE and regular English, Science and Math teacher team could easily adapt the project to fit their specific needs.

Activity 1: Introduction to the Project

Overview of Activity: Introduce the project plans to students and break the ice.

Time Frame: Half a day, not including travel to CTE

Materials List

- 20 toothpicks and 10 marshmallows per group
- Paper and pencils
- Pre-test
- Pictures of wind turbines (digital format)

Things to Do before Activity:

- Put together a slide show of wind turbines
- Determine work groups of 4 – 5 students each, mixing students from both schools
- Create pre-test (see web site)

Project Details:

Discussion Points:

- What are we going to be doing in this project?
- What do I already know about wind turbines?

Things to Do during Activity:

1. Introductions: Introduce students and teachers.
2. Slideshow: Present Power Point show of wind turbines to introduce the focus of this project.
3. Building Towers: Groups are given instructions that their job will be to build the highest tower they can using marshmallows and toothpicks. The tower has to stand on its own.
4. Document: Each group will prepare a detailed description of their tower so that it could be rebuilt using only the paper as a guide.
5. Judging: Judge the towers and choose a winner.
6. Pre-test: Students end activity by taking a pre-test for the project.

Conclusion of Activity: Talk to students about upcoming activities and time frames.

Activity 2: English Lessons

Overview of activity: Use a fun yet simple experiment to help students understand and walk through the process of making a scientific poster.

Time Frame: Three class periods

Materials List:

- A sample scientific poster
- Small bag of M&M's (1 per student)
- Blank white paper

Things to Do before the Activity:

- The idea is to find a simple experiment that yields information that can be displayed on a sample scientific poster. The teacher who developed this activity chose an M&M activity, as described below. Information on this activity can be found in the References and Resources section of this document.

- Buy M&M's (or other supplies needed for experiment).

Project Details:

Discussion Points:

- What are the important components of a scientific poster?
- How do these relate to what I already know from English class?
- Can I gather proof for my hypothesis and results?
- How does arrangement and color play an important role in my poster?
- Why is writing important to a science project?

Things to Do during Activity:

1. Class period 1
    a) Introduction: Introduce sample/pictures of scientific posters to students.
    b) Talk about each component of a scientific poster, correlating terms from English class to science class (i.e., hypothesis = thesis statement).
    c) Talk about the aesthetic values of the poster. (Note: The school's art teacher might have a few pointers for this.)

2. Class period 2
    a) Explain that throughout the experiment students should be writing the different components of the poster, starting with the paragraph hypothesis long BEFORE the M&M's bags are opened.
    b) Conduct Experiment: Students conduct the experiment and collect data. They can use each other's tallies to add to the data they have.
    c) Students will need to choose two different types of graphs to display their findings. These will need to be brought to the next class along with all of the other components. They will also be told to bring markers/colored pencils to next class. (Note: The teacher who developed this activity required typewritten work to stress neatness.)

3. Class period 3
    a) Mock-Up Design: Hand out the blank sheets of 8 1/2 x 11 papers. Students will pretend to place the components that they have made using markers or colored pencils on the paper. Provide feedback as students work. Students complete their work and it is collected by teacher for feedback.

Conclusion of Activity: Answer questions and give feedback.

Activity 3: Build and Test Day

Overview of Activity: Working in groups, students design, build and test their own wind blades. Information collected is used to make a scientific poster.

Time Frame: One day

Materials List:

- 9 x 13 Styrofoam block (one per group + a few extra)
- Cutting tool
- Testing "windmills"
- Laptops for collecting data in PowerPoint, one per group
- Weights to test lifting ability
- Electric fans (one per "windmill")
- Paper and pencils for design work
- Access to a large format printer for printing of scientific posters.

Things to Do before the Activity:

- Make the "windmills". (Note – the students will be designing and building the blades, the intent here is to construct the remainder of the wind mills.)
- Verify that the poster printers are compatible with PowerPoint.

Project Details:

Discussion Points:

- What do I need to record to reproduce this blade 3 times?
- Who is the 'scribe' and what does he/she need to be writing down/typing?
- How should we design our poster?

Things to do during activity:

1. Design: After being assigned to groups, students will start designing a blade on paper. When a group has a "good" design, it will be approved by a teacher.

2. Building Design: Students, once design is approved, are given Styrofoam and a cutting tool.

3. Test: When a group has completed constructing three blades, the blades are brought to a testing station that has the 'mill' and an electric fan set up. Each group can make quick adjustments at the testing station or larger adjustments back at their table.

4. .Data Collection: Once three working blades are created each group will decide what data they wish to collect. Some examples are:

    a) How long does it take to lift 5 weights, then 10 weights and so on?
    b) Does the angle of the blade affect the speed of lifting?

5. Posters: Using data from the wind turbine test, students design scientific posters to summarize and convey their findings. If time allows, the posters can be printer during activity time.

Activity 4: Presentation (optional)

Overview of activity: Students are given the opportunity to present their posters to friends and family and practice their speaking skills.

Students on a field trip to the University of Maine's Advanced Engineering Composite Center

Timeframe: 1-2 hours

Materials List:

- Tables and/or easels for poster and blades and lab notes
- Refreshments, if desired
- Prizes and/or certificates, if desired

Things to do before the activity:

- Reserve auditorium or room for presentations
- Invite a TV channel, if desired
- Send invitations to student's families
- Announce presentation to other students
- Arrange for judges and determine judging criteria
- Make a schedule of the event: Are students going to each talk about their project/poster or will it be science fair style?

Project Details:

Discussion Points:

- Give students tips on how to present their work and answer questions.

Things to Do during Activity:

1. Prepare the room and enjoy the show. Let students see that you are proud of them.

Conclusion of Activity: Emcee the event by announcing prizes and thanking guests for coming.

Suggested Field Trips

The following field trips were incorporated into the wind turbine project:

- **Rollins Mountain Field Trip:** Students from both schools took a trip to Lincoln, Maine to observe an actual windmill farm and to meet with its designers. Engineers from Reed and Reed, Sargent Corporation and First Wind were invited to speak to students about building the 40 wind turbines at the farm. Class discussions were held in students home schools to review the information they heard.

- **University Field Trip:** Students went to University of Maine's Advanced Engineering Composite Center to tour the facility, observe testing, and learn from the experts. At the time of the tour, the center was in the process of building a test site for wind blades. Students were able to hear how the blades would be tested and see actual wind turbine blades awaiting testing.

Reflections by Shari Arnold (Bangor Christian), John Milligan (United Technologies Center) and Emily Spaulding (Bangor Christian):

Throughout this project, students were exposed to many aspects of wind turbine technology: the engineering and testing of blades, the mechanics of running a turbine, and the generation of electricity at a functioning wind farm. One of our major goals as developers of the project was to ensure that students had the opportunity to put their newfound knowledge of wind turbines to use through the engineering-design process. From our point of view, the most significant gain that we observed in students was their ability to design a functioning blade. At both the beginning and end of the project we asked students to draw what they thought a blade should look like. After the project, many of the drawings were more sophisticated in terms of shape, detail, and dimensions. This difference came from the fact that students were able to synthesize information from not only the trips we took but the testing of their blades but each others' knowledge. Another important area of growth for our students was in their ability to work as a team to design and test a blade that would lift a pre-determined mass. Many groups of students had to rework their designs several times, but the group dynamic of CTE plus regular science classroom students proved invaluable in their motivation and dedication to their goal. Our initial hope at the beginning of the project was to host a "poster session," during which groups could display their designs to fellow students, family, and members of the outside community. Unfortunately, we ran out of time and did not include this piece in our project. However, in the future we hope to add this very crucial final step as a way for students to communicate their work as well as take complete ownership of it.

A special note from the English Teacher (Shari Arnold):

As the English teacher on the team I wondered how I could fit in with MMSA. But it didn't take long for me to see the need. I taught a short series of three class periods to my English class that involved the same students that were in the science class (plus 4). In the lessons we talked about a scientific poster and what it should include in it. We also talked about audience and voice and what is a good source and how display the facts and graphs logically. All of this information translated easily from the English forum they were used to seeing me in to the world of science. 'Thesis' related to 'hypothesis' and lights went on as students saw connections between the two classes. I was able to use a scientific poster lent to me by MMSA and Jackson Lab. That was a big help but there are pictures of them online as well. Some of the class time was involved in a fun food experiment that was quick and simple but gave them a practice session 'designing' their own scientific poster before the big wind blade experiment day.

Resources/References

1. Material relating to goals, objectives, lessons and other supporting information was provided by the three instructors who developed this project: Shari Arnold of Bangor Christian School, John Milligan of UTC and Emily Spaulding of Bangor Christian School.

2. http://www.sciencebuddies.org/science-fair-projects/project_ideas/Math_p021.shtml for M&M's experiment

Examples and additional materials mentioned in this project can be found at: http://mmsa.org/highlights/learn-m4cte-project-guides

Windows and Doors

By Irene Haskins, edited by Jessica McGreevy

Project Developers:

- Rebecca Shields, 9th Grade Mathematics Teacher, Oceanside West High School, Thomaston ME
- Dan Dishner, Residential Construction Instructor, Mid-Coast School of Technology, Rockland ME

This project is all about finding "half". While that may seem like a simple concept, it provides a wealth of mathematical learning and plays a very important role in building construction.

Preface

This project provides a fun and interesting way to encourage students to learn about fractions. Anyone involved in construction encounters fractions. Finding the half width of a door or window makes a good illustration of how fractions are used in the construction industry. This project focuses on that half width, but also touches upon how to use scale drawings. Students will use building plans and a measuring device to accurately layout window openings for a wall.

Why do this project?

The power of this project lies in engaging students in a fun and interactive activity that gets them using fractions. Students will learn how important building plans, measurement and mathematics are in the construction of buildings. Students will also learn about what "scaling" means, how to convert scaled dimensions to real dimensions and convert real dimensions to scaled dimensions, how to read and use blue prints and change measurement units. This project finishes with students laying out a full-scale model of a wall using drywall tape.

This project was developed as a collaboration between a "regular"[4] high school teacher and a Career Technical Education (CTE) teacher. The partnership was a key element in the success of the project, benefitting both teachers and most of all, students.

[4] The term "regular" high school is meant to distinguish a traditional high school from a Career Technical Education high school. The same term will be used for students attending these schools. There is not an easy way to identify these students from the CTE students, so the word "regular" will be used for clarity.

Common Core State Standards for Mathematical Practice:

- *CCSS.Math.SMP.2 – Reason Abstractly and Quantitatively*
- *CCSS.Math.SMP.4 – Model with Mathematics*
- *CCSS.Math.SMP.5 – Use appropriate Tools Strategically*

Common Core State Standards- Mathematics:

- *CCSS.Math.7.G.1 – Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.*
- *CCSS.Math.6.NS.1 - Interpret and compute quotients of fractions, and solve word problems involving division of fractions by fractions.*

Overview of the Project

When architects draw blueprints for a building, they only give the model number of the windows (the same holds true for doors). It is up to the builder to find the "rough openings" for the windows using the "window tables" or charts in the manufacturer's book. Most blue prints show window and door locations from outside corner to center of rough opening. In order to properly layout the window opening, the builder needs to be able to find the center of each opening and include half of the rough opening on either side of center. It is not uncommon that the half way mark involves fractions.

Although the concept of "half" of a window width is simple, to be able to measure half a window requires mathematics and some background knowledge in construction. To complete this project successfully, students will need to know about blueprints, scaling, construction terminology and measurement.

Students will be working with real blue prints and actual manufacturer's window specifications in order to determine half-widths of windows. They will then lie out a full-size wall frame showing proper window placements.

What Will Students Learn?

- Use of proper tools for measurement
- Use of correct mathematical procedures
- How to read and interpret the floor plan of a blueprint
- How to convert a scale drawing to real measurements
- How to convert measurements to scale
- How to use a measuring device to accurately layout door and window openings.
- Some building construction basics, such as laying out a wall at 16" on center for common studs
- How to find rough openings in a window specification book

The Benefits of Collaboration

This project was developed as a collaboration between a 9th grade mathematics teacher at Oceanside West High School, Thomaston and a residential construction teacher at the Mid Coast School of Technology. The collaboration was critical giving the regular high school students access to residential construction facilities. Additionally, the teachers were able to pool their expertise in mathematics and building construction.

Toolkit – Everything You Need to Do This Project

This section describes two suggested activities for this project. Supporting information can be found in the Resources/References section of this paper.
This is an example of what the teachers who developed this project put together for their students. Any CTE and math teacher team, to fit their specific needs, could easily adapt this project.

Where's the Math?

In this project, students will use fractions, unit conversions and will learn to work with scaled measurements.

Activity1: Building Construction Basics – Plans and Half-Width

Overview of Activity: Introduction to building construction, building plans, scale and finding half.

Time Frame: About 2 hours

Materials List:

- Manufacturer specifications for several window models (The teachers in this project used a measurement sheet for Andersen 400 Series Casement windows.)
- Copies of blueprints for students to use
- Pencils
- Tape measures
- Finding Half Worksheet – one per student (see example on website)
- Window measurements worksheet – one per student (see example on website)

Things to Do before Activity:

- Make copies of blue prints.
- Prepare a layout for students to use to check accuracy.
- Prepare the finding half and window measurement worksheets.
- Prepare pre-test: Suggested topics include converting lengths to inches, converting inches to feet, given a sketch of a wall denoting rough openings for windows, find the centerline of the window openings, determine widths and girder placement.

Activity Details:

Discussion Points:

- Terminology: rough openings for windows, half width, centerline, unit conversions.
- How to work with scaled drawings and take measurements.
- Why blueprints/plans are critical in building construction.

Things to Do during Activity:

1. Introduction to Activity: Students start the activity by taking a pre-test.

2. Measurement Conversion: Students will complete a worksheet on finding half of 5 different measurements that are given in terms of feet and inches.

3. Scale Models and Plans: Students are shown a scale model wall and a floor plan from Point Lookout.

4. Exterior Wall Parts: Use graphic frame wall members to identify exterior wall frame parts.
5. Measurement Practice: Using manufacturer's specifications, students will complete a worksheet to find the height, width and half the width for 4 specific windows.

6. Finding Half Widths: Students will be asked to find half of each rough opening on a building plan.

Conclusion of Activity: Wrap up of material covered for day. Then, introduce the next part of the project to students: they will be laying out a wall from blueprints at 16 inches on center with proper location of all rough openings.

Activity 2: Layout a Wall

Overview of Activity: Students will layout a wall frame in actual size with tape using blueprints at 16 inches on center. The wall frame is laid out on the floor.

Time Frame: About 2 hours.

Materials List

- Manufacturer specifications for several window models (the teachers in this project used a measurement sheet for Andersen 400 Series Casement windows)
- Blueprint plans of wall
- Joint compound tape for wall layout
- Pencils
- Tape measures
- Speed squares to mark stud locations

Things to Do before Activity:

- Make copies of blue prints.
- Prepare a layout for students to use to check accuracy.
- Make copies of post-test (same questions as pre-test).

Activity Details:

Discussion Points:

- Review terminology: Common studs, trimmers, kings, cripple studs.
- How to use a marking trimmer.
- How to layout frame on floor.

Things to Do during Activity:

1. Introduction/Terminology: After a brief introduction to the day's activity, students will learn about laying common studs on center and how to mark trimmers, kings and cripple studs.

2. Measuring and Locating: Each student will be given a blueprint of a wall showing rough openings for the windows. They will need to locate the centerline for 2 windows, mark the trimmers and kings and cripple studs.

3. Layout wall frame: Using the plan and the measurements found, students will layout and mark the wall on the floor using tape.

4. Compare finished product: Each student's finished product will be compared to "correct" wall layout.

Conclusion of Activity: Students will take a post-test of the same topics as on pre-test. Teachers should wrap-up the event by talking about the project.

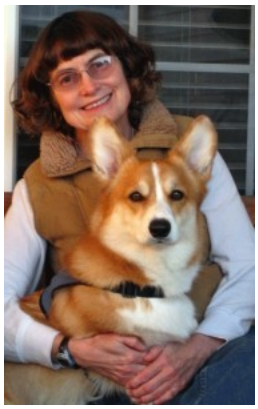
Resources/References

- Material relating to goals, objectives, lessons, activities and other supporting information was provided by the teachers who developed this project: Rebecca Shields , 9th grade mathematics, Oceanside (West) and Dan Dishner, Residential Construction, MCST

- http://www.andersenwindows.com/servlet/Satellite/AW/Page/awGeneral-3/1132096528395 Product details for Anderson 400 Series windows.

Examples and additional materials mentioned in this project can be found at: http://mmsa.org/highlights/learn-m4cte-project-guides

NOTES



Irene Haskins:
ihaskins@mmsa.org

Jessica McGreevy
jmcgreevy@mmsa.org

Maine Mathematics and Science Alliance
PO Box 5359
Augusta, ME 04332
Phone: 207-626-3230
fax: 207-287-5885

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