STEM Success:
STEM Ed Quality Framework

Liz Wolfe-Eberly

The Dayton Regional STEM Center
Science, Technology, Engineering and Math

What is the DRSC?

- The Dayton Regional STEM Center is based in Dayton, Ohio and has served districts and communities throughout its region and throughout the nation.
- Facilitates the STEM Fellows program - a seven month professional development program designed to enhance pedagogical content knowledge and help
- Develops and makes quality STEM lessons available online for free.
- Is the pipeline for workforce development in the Dayton area.

NATIONAL NEED

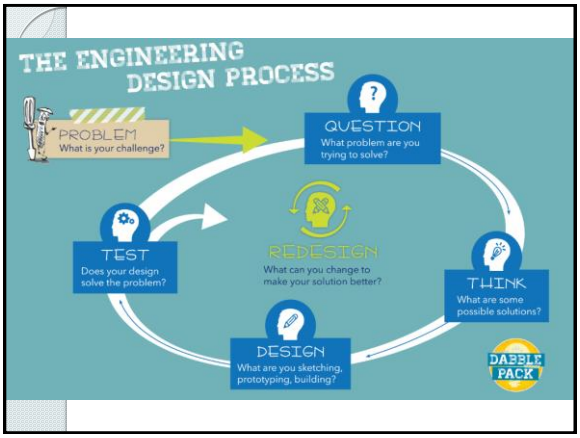
- There is a general level of **STEM literacy** necessary to be an informed consumer and productive member of society.
- There is a well-documented **skills gap** of graduates and available jobs
- 65% of today's grade school kids will end up at a **job** that has not been invented yet.
- Teachers, service providers and parents seek **increased learner engagement.**
- Research in best practice documents the profound impact of **problem-based learning** experiences on concept attainment and application.
- Research in **career development** documents that development of the self-concept is life-long. Students must be explicitly exposed to career connections throughout their academic careers.
- Research on **female learners** documents significantly improved learning in collaborative environments.

Brief video: What is the STEM Crisis

EXPLORING STEM EDUCATION

> "Tell me and I forget. Teach me and I remember. Involve me and I learn."
>
> Benjamin Franklin

The Journey of a STEM Fellow...



ENGINEERING CHALLENGE

- Your team will have 20 minutes to design and engineer a water transport system that commences at one end/ corner of the table and is completed at the opposite end/corner of the table.
- The design must run the length of the table and not touch or pass over the piece of paper in the center of your table which represent buildings.
- The collection tub will sit at the end of the table, flush with the table surface.
- The design must include at minimum one 90 degree angle and two 45 degree angles, successfully transporting the water source to the basin.
- The tablecloths may not be used in your designs.
- Your structure will be tested for speed of water movement and volume transported.

Failure is not just an option...

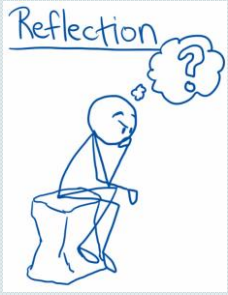
It is mandatory!!!

This is a tough concept for ***both teacher and student!***

Engineers have "Failure Analysis" meetings

Hospitals and doctors have "Morbidity and Mortality" conferences (although we don't want them to fail!!)

DEFINING HIGH-QUALITY STEM EDUCATION



Let's use this engineering experience to explore components of STEM Education for strengths and areas of growth.

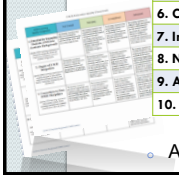
STEM vs. STEM Education

STEM is an acronym for Science, Technology, Engineering and Math it is not a process or product.

STEM Education is an interdisciplinary approach to teaching and learning where age-appropriate concepts are embedded in real-world learning experiences in which participants apply science, technology, engineering, and mathematics to make connections between school, society and work in an effort to develop STEM literate population and workforce.

COMPONENTS OF HIGH-QUALITY STEM ED.

STEM Education Quality Framework
1. Potential for Engaging Students of Diverse Academic Backgrounds
2. Degree of STEM Integration
3. Connections to Non-STEM Disciplines
4. Integrity of the Academic Content
5. Quality of the Cognitive Task
6. Connections to STEM Careers
7. Individual Accountability in a Collaborative Culture
8. Nature of Assessments
9. Application of the Engineering Design
10. Quality of Technology Integration



Architect: Dr. Jim Rowley

What it is....	*What it is not...*
A guide to scaffold STEM Fellows and PK-12 teachers in the STEMed instructional design process.	A prescriptive methodology for teaching science, technology, engineering, or mathematics.
A set of principles that provide a conceptualization of the teaching and learning context in which quality STEMed might be situated	A substitute for the NSTA, NCTM, ISTE, or NAE standards.
A cognitive tool for promoting teacher reflection and self-assessment.	A substitute for research-based, content-specific pedagogies in math or science education.
A vision of STEMed that provides a common set of principles and language to promote dialogue between and among STEMed stakeholders.	A formulaic approach to STEM education that de-values the role of teachers as curriculum designers and assessment specialists.
A formative assessment tool for STEMed leaders to use in planning professional development experiences for classroom teachers.	A classroom observation tool for supervisors to use in the summative evaluation of classroom teachers.

STEM EDUCATION QUALITY FRAMEWORK

Supports:

Providing rich engineering based experiences in a standards based classroom is a complex conversation.

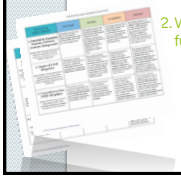
The STEM Education Quality Framework is an educational tool that can guide your instruction

Using the STEM Education Quality Framework is like operating an Audio Equalizer.

COMPONENT 1: POTENTIAL FOR ENGAGING STUDENTS OF DIVERSE ACADEMIC BACKGROUNDS

Quality STEM learning experiences are designed to engage the minds and imaginations of students of diverse academic backgrounds.

1. How did this STEM lab support this component?
2. What could be done to enhance this component in future implementation ?



COMPONENT 2: DEGREE OF STEM INTEGRATION

Quality STEM learning experiences are carefully designed to help students integrate knowledge and skills from Science, Technology, Engineering, and Mathematics

1. How did this STEM lab support this component?
2. What could be done to enhance this component in future implementation ?

COMPONENT 3: CONNECTIONS TO NON-STEM DISCIPLINES

Quality STEM learning experiences help students connect STEM knowledge and skills with academic standards from other disciplines.

1. How did this STEM lab support this component?
2. What could be done to enhance this component in future implementation ?

COMPONENT 4: INTEGRITY OF THE ACADEMIC CONTENT

Quality STEM learning experiences are content-accurate, anchored to the relevant content standards, and focused on the big ideas and foundational skills critical to future learning in the targeted discipline(s).

1. How did this STEM lab support this component?
2. What could be done to enhance this component in future implementation ?

COMPONENT 5: QUALITY OF THE COGNITIVE TASK

Quality STEM learning experiences challenge students to develop higher order thinking skills through processes such as inquiry, problem-solving, and creative thinking.

1. How did this STEM lab support this component?
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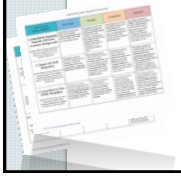

COMPONENT 6: CONNECTIONS TO STEM CAREERS

Quality STEM learning experiences place students in learning environments that help them to better understand and personally consider STEM careers.

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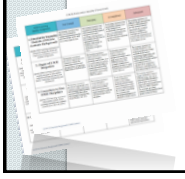
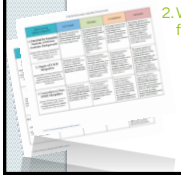


COMPONENT 7: INDIVIDUAL ACCOUNTABILITY IN A COLLABORATIVE CULTURE

Quality STEM learning experiences often require students to work and learn independently and in collaboration with others using effective interpersonal skills.

1. How did this STEM lab support this component?
2. What could be done to enhance this component in future implementation ?



COMPONENT 8: NATURE OF ASSESSMENT(S)

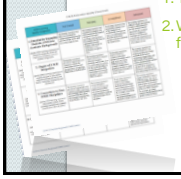
Quality STEM learning experiences require students to demonstrate knowledge and skill, in part, through performance-based tasks.

1. How did this STEM lab support this component?
2. What could be done to enhance this component in future implementation ?

COMPONENT 9: APPLICATION OF THE ENGINEERING DESIGN PROCESS

Quality STEM learning experiences require students to demonstrate knowledge and skills fundamental to the engineering design process (e.g., brainstorming, researching, creating, testing, improving, etc.).

1. How did this STEM lab support this component?
2. What could be done to enhance this component in future implementation ?



COMPONENT 10: QUALITY OF TECHNOLOGY INTEGRATION

Quality STEM learning experiences provide students with hands-on experience in using multiple technologies. (Examples: computer hardware and software, calculators, probes, scales, microscopes, rulers and hand lenses to name just a few).

1. How did this STEM lab support this component?
2. What could be done to enhance this component in future implementation ?

STEM EDUCATION QUALITY FRAMEWORK

Supports evolution of diversity and rigor of STEM offerings!

Questions

DRSC RESOURCES

Free Resources

- Free online curriculum
- Free STEM Education Quality Framework
- Free Career Videos

Services

- Annual STEM Conference
- www.annualstemconference.com
- Consultation
- Customized Services
- Mentoring
- Professional Development
- Programming Analysis/ Audits
- Program Design
- Program Implementation
- Training

Visit us at:
www.daytonregionalstemcenter.org

THE ENGINEERING DESIGN PROCESS

PROBLEM
What is your challenge?

QUESTION
What problem are you trying to solve?

THINK
What are some possible solutions?

DESIGN
What are you sketching, prototyping, building?

TEST
Does your design solve the problem?

REDESIGN
What can you change to make your solution better?

STEM Center

MONTGOMERY COUNTY EDUCATIONAL SERVICE CENTER

DABBLE PACK

NEW AGE AQUEDUCT

Mock Lesson
7th Grade

Unit Overview:

Given specific constraints, students apply energy transformations as they design a water collection and transport system. Teams of students will collaborate to assist community gardeners, especially the handicap, collect and transport water to their plants. Students will employ the engineering design process as they design an energy-efficient prototype system for collecting rainwater and transporting it to the garden with maximum speed. After completing and testing their system, students investigate how the water transfers through the hydrologic cycle, one of Earth's biogeochemical cycles.

Unit Timeframe:

Day	Time	Activities
1	50 minutes	Pre-Test Introduction to Gardening and Historical Trends
2	50 minutes	Introduction to the Engineering Design Challenge Career Assignment and Code of Cooperation
3	50 minutes	Decision Analysis Matrix: Design Selection
4	50 minutes	Prototype Construction
5	50 minutes	Prototype Construction
6	50 minutes	Prototype Testing and Data Analysis
7	50 minutes	Multimedia Presentation Development
8	50 minutes	Presentations
9	50 minutes	Gardening and the Hydrologic Cycle
10	50 minutes	Post-Test

Engineering Design Challenge:

Members of a local community garden are struggling to collect and transport water to their plants. Currently gardeners and volunteers carry buckets of water to the plants, but some gardeners are handicapped and unable to easily transport the buckets. Community garden members have requested your assistance in designing an efficient system for collecting rainwater and transporting it to the garden. They have requested that you provide them with a brief presentation and prototype of the proposed water collection and transport system.

- ✓ Use only the available materials.
- ✓ Complete your working prototype by the end of day 5.
- ✓ Provide a scaled sketch of your team's final design.
- ✓ Collect and hold 100 mL of water in your collection container until released to quickly transport 1.5 m (4.92 ft.) from your rainwater collection container to the garden model provided by your teacher.
- ✓ Present data to prove your design is energy-efficient and provides maximum speed.

Academic Content Standards:

Mathematics

Grade	7
Domain	Ratios and Proportional Relationships
Cluster	Analyze proportional relationships and use them to solve real-world and mathematical problems.
Standards	Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units.

Grade	7
Domain	Geometry
Cluster	Draw, construct, and describe geometrical figures and describe the relationships between them.
Standards	Solve problems involving similar figures with right triangles, other triangles, and special quadrilaterals. a. Compute actual lengths and areas from a scale drawing and reproduce a scale drawing at a different scale.

Science

Grade	7
Theme	Order & Organization
Topic	Cycles and Patterns of the Earth and Moon
Content Standard	The hydrologic cycle illustrates the changing states of water as it moves through the lithosphere, biosphere, hydrosphere an atmosphere.

Grade	7
Theme	Order & Organization
Topic	Conservation of Matter & Energy
Content Standard	Energy can be transferred through a variety of ways.

Social Studies

Grade	7
Theme	World Studies from 750 B.C.E to 1600 C.E.: Ancient Greece to 1st Global Age
Strand	Geography
Topic	Human Systems
Content Standard	Geographic factors promote or impede the movement of people, products, and ideas.

English Language Arts

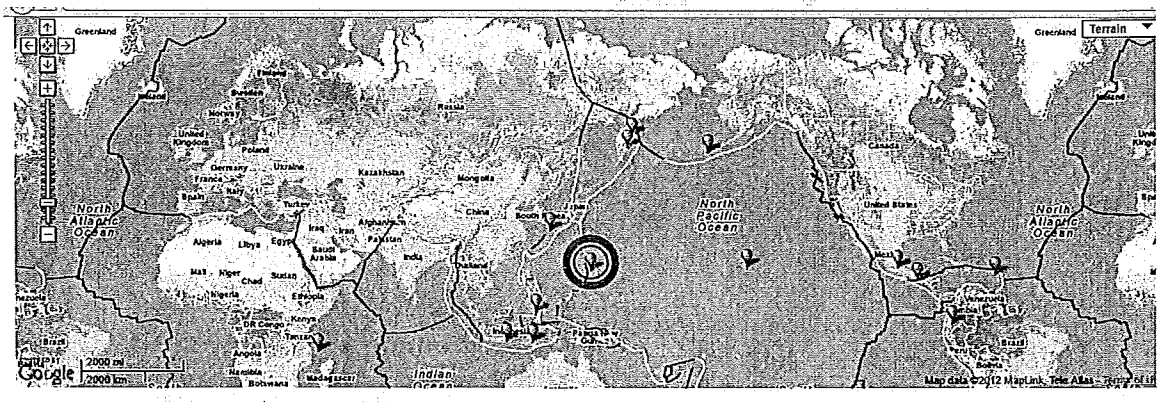
Grade	6-8
Strand	Literacy on Science and Technical Subjects
Group	Integration of Knowledge and Ideas
Standard	Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.

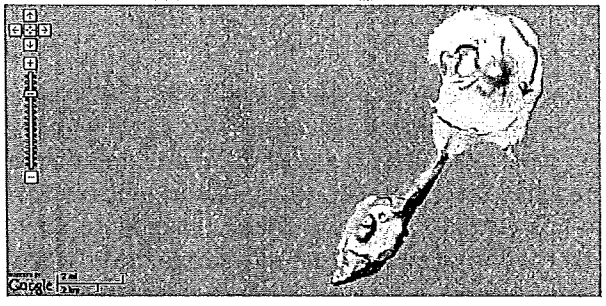
Cantilever Bridge Mock Lesson Plan
8th Grade

Pagan Island: Mariana Islands
Summit elevation: 570 meters

According to NASA's Earth Observatory, a satellite image of Pagan acquired on 10 October showed a gas-and-steam plume drifting west. The plume's blue tint suggested the presence of sulfur dioxide; elevated levels of sulfur dioxide to the W of the volcano were detected in satellite images later that day. The USGS reported that minor steam-and-gas plumes were observed in partly cloudy satellite images during 5-12 October. The Volcano Alert Level remained at Advisory.

Pagan Island, the largest and one of the most active of the Mariana Islands volcanoes, consists of two stratovolcanoes connected by a narrow isthmus. Both North and South Pagan stratovolcanoes were constructed within calderas, 7 and 4 km in diameter, respectively. The 570-m-high Mount Pagan at the NE end of the island rises above the flat floor of the caldera, which probably formed during the early Holocene. South Pagan is a 548-m-high stratovolcano with an elongated summit containing four distinct craters. Almost all of the historical eruptions of Pagan, which date back to the 17th century, have originated from North Pagan volcano. The largest eruption of Pagan during historical time took place in 1981 and prompted the evacuation of the sparsely populated island.





Pagan Island

Active Volcanos
(using the Google Maps API)

Volcano Activity Reports are available from:
the Smithsonian Institute (USGS Weekly Volcanic Activity Report)
and the VOLCANO mailing list
Database and additional information from:
Smithsonian Institution, Global Volcanism Programhttp://www.geocodezip.com/v2_activeVolcanos.asp

Unit Overview:

Student teams will work collaboratively to develop prototypes of cantilever bridges that are able to allow Pagan Island inhabitants to rescue their native species from lava flow from recent volcanic eruption. Then, student teams will participate in a jigsaw activity where individual students will investigate various types of volcanic activity and the native species of Pagan Island. Based on their review of case studies of repetitive volcanic activity, students will report back to their group regarding the plate tectonic movement that causes them, as well as the endangered species the Pagan Island officials are attempting to rescue. Based on Pagan Island location, students will identify the type of plate boundary or activity is found at this location. After identifying the type of boundary, students will utilize United States Geological Survey Data, to see if they could potentially predict the future volcanic activity at Pagan Island. Once individual activities are complete, student teams will reconvene to brainstorm possible construction solutions to the problem. After a team ideation, student teams will work to develop cantilever prototypes and then test their designs using weights to test their cantilever until failure. After testing, students will have the opportunity to redesign before submitting a final written report and building instructions to the Pagan Island government for use in this disaster relief.

Activity Outline:

Day	Activities
1	Pre-Test/Volcanic Activity
2	Plate Tectonics and Native/Endangered Species Jigsaw Activity
3	Plate Tectonics and Native/Endangered Species Jigsaw Activity
4	Pagan Island Volcanic Activity Prediction Activity
5	Team Ideation/Brainstorming
6	Engineering Design Challenge Construction
7	Engineering Design Challenge Construction
8	Failure Analysis Testing
9	Redesign & Retesting
10	Data Analysis and Report Generation
11	Report Generation and Post-Test

Engineering Challenge Objective:

You have been tasked to design a model cantilever for disaster relief on Pagan Island. After the volcanic eruption, several native species are trapped by the volcanic destruction. To preserve biodiversity, island natives would like to build a structure from safe land that extends over the lava flow to attempt to save these animals. Island inhabitants have ready access to long, thin, brittle wood; a gum substance and an industrial material that may serve as a binding tape. In an attempt to prepare for incoming cantilever design directions, the officials have formed a team that is starting to apply the adhesive to the industrial binding to create a wide binding similar to masking tape but on a much larger scale. As Civil Engineers it is your job to utilize the tools and materials provided to construct a cantilever structure that extends as far from the edge of the table as possible without relying on an additional support system (such as the ground). The structure may be attached to only the top of the table. Engineering teams must provide an accurate measurement of the length the cantilever extends from the edge of the building at close of the challenge timeframe. The goal is to create a scale model of a cantilever the officials could use to create a bridge to span the affected part of the island in order to help rescue native species that have

survived the initial volcanic eruption. Due to location and volcanic activity officials must work fast in their rescue attempt before the next eruption occurs.

Background Knowledge:

Cantilever: A long projecting beam or girder fixed at only one end, used chiefly in bridge construction.

Civil engineering: is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including works like roads, bridges, canals, dams, and buildings.[1][2][3] It is traditionally broken into several sub-disciplines including environmental engineering, geotechnical engineering, structural engineering, transportation engineering, municipal or urban engineering, water resources engineering, materials engineering, coastal engineering,[4] surveying, and construction engineering.[5] Civil engineering takes place on all levels: in the public sector from municipal through to national governments, and in the private sector from individual homeowners through to international companies.

http://en.wikipedia.org/wiki/Civil_engineering

1. ^ The American Heritage Dictionary of the English Language, Fourth Edition. Houghton Mifflin Company, 2004. [1] (accessed: 2007-08-08).
2. ^ "History and Heritage of Civil Engineering". *ASCE*. http://live.asce.org/hh/index.mxml?versionChecked=true. Retrieved 2007-08-08.
3. ^ "Institution of Civil Engineers What is Civil Engineering". *ICE*. http://www.ice.org.uk/downloads//little_book_full_colour.pdf. Retrieved 2007-09-22.
4. ^ a b c "What is Civil Engineering?". *The Canadian Society for Civil Engineering*. http://whatiscivilengineering.csce.ca/civil1.htm. Retrieved 2007-08-08
5. ^ a b c Oakes, William C.; Leone, Les L.; Gunn, Craig J. (2001). *Engineering Your Future*. Great Lakes Press. ISBN 1-881018-57-1

Associated Academic Content Standards:

English Language Arts

Grade: 8
Strand: Writing Standards 6-12
Topic: Text Types and Purposes
Standard: 2. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. b. Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate transitions to create cohesion and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style. f. Provide a concluding statement or section that follows from and supports the information or explanation presented.

Mathematics

Grade: 8
Domain: Geometry
Cluster: Understand and apply the Pythagorean Theorem
Standard: 7. Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.

Science

Grade: 8
Theme: Earth and Space Science
Topic: Physical Earth
Content Standards: Physical world maps, cross sections, models (virtual or 3D) and data must be used to identify plate boundaries, movement at the boundary and the resulting feature or event. The relationship between heat from Earth's core, convection in the magma and plate movement should be explored. World distribution of tectonic activity of possible interest should be investigated (e.g., Ring of Fire, San Andreas Fault, Mid-Atlantic Ridge, Mariana Trench, Hawaiian Islands, New Madrid Fault System). Volcanic activity, earthquakes, tsunamis, geysers, hot springs, faults, oceanic vents, island arcs, hot spots and rift valleys should all be included in the identification of plates and plate boundaries. Plate boundary identification (converging, diverging, transform) must be based on the resulting features or events. The focus must be on the cause of plate movement, the type and direction of plate movement and the result of the plate movement, not on memorizing plate names.
Grade: 8
Theme: Life Science
Topic: Species and Reproduction
Content Standards: The fossil record documents the variation in a species that may have resulted from changes in the environment. The fossil record is contained within the geologic record (ESS grade 8). Combining data from the geologic record and the fossil record, Earth's living history can be interpreted. Data and evidence from the fossil record must be used to develop further the concepts of extinction, biodiversity and the diversity of species. Diversity can result from sexual reproduction. The sorting and combination of genes results in different genetic combinations, which allow offspring to be similar to, yet different from, their parents and each other. (This statement must be connected to the grade 8 Life Science content statement on reproduction and Mendelian Genetics.) These variations may allow for survival of individuals when the environment changes. Diversity in a species increases the likelihood that some individuals will have characteristics suitable to survive under changed conditions.