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Spring 2-28-2015

Engineering The Future: A Summer Academy for Underrepresented Students

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Engineering the Future: A Summer Academy for Underrepresented Students

NEXT GENERATION SCIENCE STANDARDS
For Our Children For Our Future

Before we begin: Find a couple of friends (or make a few new ones) and pick up a zip lock bag of supplies

Your task: To build the tallest free-standing structure out of 20 sticks of spaghetti, one yard of tape, one yard of string and a marshmallow. The marshmallow has to be on top.

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Engineering the Future: A Summer Academy for Underrepresented Students

Pure Michigan Science
Engineering Grand Ideas in Science
Amway Grand Plaza Hotel, Grand Rapids, MI

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Partnerships and Schools

- Hope College Natural and Applied Sciences and Social Sciences Divisions
- Muskegon Area Intermediate School District Math and Science Center
- Muskegon Heights Public School Academies
- Holland New Tech High School

Funding

- Michigan Space Grant Consortium
- Hope College
  - Natural & Applied Sciences and Social Sciences Divisions
  - Center for STEM Inquiry (Howard Hughes Medical Institute Grant)

Michigan Space Grant Consortium NASA

HHMI HOWARD HUGHES MEDICAL INSTITUTE

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The Marshmallow Challenge

- Who Consistently Performs Poorly?
  - Recent Business School Graduates
- Who Consistently Preforms Well?
  - Recent Kindergarten School Graduates
- Why?
  - Business students tend to strive for the one best solution and only after the structure is built do the see if it will hold a marshmallow
  - Kindergarten Students – engage in the natural design process; smaller steps, testing materials and seeing what works as they plan and build prototypes arriving at a solution – **an engineering approach**

The Marshmallow Challenge Website with TED Talk Video is at http://marshmallowchallenge.com/Welcome.html

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Engineering? but I teach Science!

Table 2. Framework for comparison review of the NGSS and MSS Grade Level Content Expectations for Grades K-7

NGSS		MSS
Scientific and Engineering Practices	↔	**Science Processes**
Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information		Inquiry Process Inquiry Analysis and Communication Reflection, and Social Implications
Crosscutting Concept	↔	**Disciplines**
Patterns Cause and effect Scale, proportion, and quantity Systems and system models Energy and matter Structure and function Stability and change		Physical Science Force and Motion Energy Properties of Matter Life Science: Organization of Living Things Heredity Evolution Ecosystems Earth Science Earth Systems Solid Earth Fluid Earth Earth in Space and Time
Disciplinary Core Ideas	↔	**Disciplines (all of the above)**
Physical Sciences Life Sciences Earth and Space Sciences		Physical Science Life Science Earth Science
Disciplinary Core Ideas	↔	**Science Processes**
Engineering, Technology and Application of Science		Inquiry Reflection, and Social Implications

A Content Comparison Analysis of the Next Generation Science Standards and the Michigan Science Standards (Ziker , 2014, p. 9).

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Science and Engineering Practices in the NGSS

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

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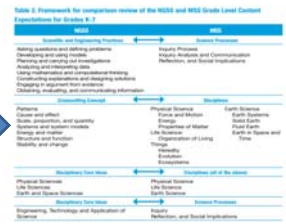
Real World Inquiry and the NGSS

- Cross Cutting Concepts
  1. Patterns
  2. Cause and effect
  3. Scale, proportion and quantity
  4. Systems and system models
  5. Energy and matter
  6. Structure and function
  7. Stability and change



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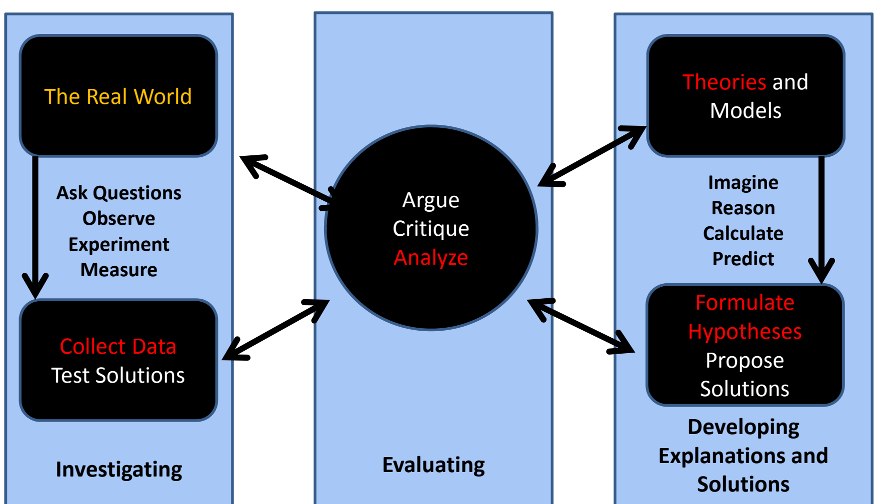
Scientists and Engineers Areas of Activity

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas



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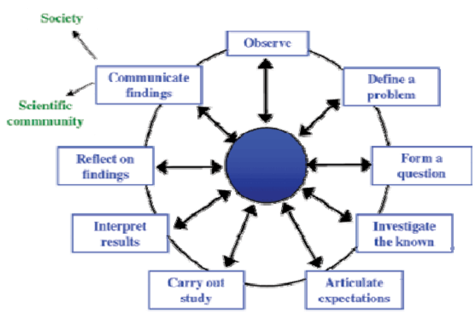
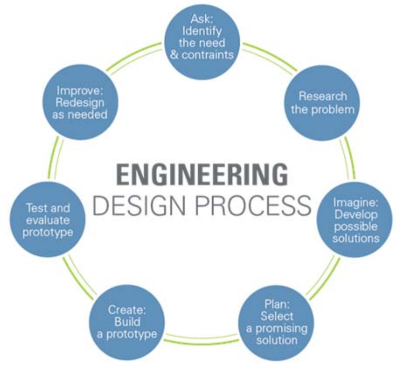
Scientific Method



Redrawn from "A Scientific Method Based on Research Scientists' Conceptions of Scientific Inquiry," R. Reiff, W. S. Harwood, T. Phillipson. Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science.

Engineering Design



https://www.teachengineering.org/engrdesignprocess.php

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Engineering? but I teach Science!

Table 3. Results of the NGSS and the MSS Grade Level Content Expectations for K-7 Content Comparison Analysis

Next Generation Science Standards	Michigan Science Standards for K-7	Degree of Match
Scientific and Engineering Practices	Science Processes	Low Match
NGSS Crosscutting Concepts	MSS Disciplines	Low Match
NGSS Disciplinary Core Ideas	MSS Disciplines	Moderate Match
Overall Degree of Match		**Low to Moderate Match**

The NGSS Scientific and Engineering Practices and MSS Disciplines of Science Processes were fairly similar in how they address science; however, only the NGSS include references to engineering, developing and using models, and using mathematics and computational thinking.

A Content Comparison Analysis of the Next Generation Science Standards and the Michigan Science Standards (Ziker, 2014, p 16).

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Engineering the Future Academy
Summer 2014

The Center for STEM Inquiry at Hope College

- Public support for STEM education
- Saturday programs

- Summer high school academies
- Teacher workshops

- Education student field placements
- Student leadership and training

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Engineering The Future Academy
Goals/Rationale

- **motivate students to learn math and science concepts** by illustrating relevant applications.

- **fosters problem-solving skills**, including problem formulation, iteration, and testing of alternative solutions.

- embraces project-based hands-on learning, and sharpen **abilities to function in three dimensions**

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Engineering The Future Academy Goals/Rationale

- **increase students' awareness of and access to scientific and technical careers**—to consider engineering as a career, so that they enroll in the necessary science and math courses in high school.
- **Engineering and technological literacy are necessary for the 21st century.**

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Approach

- Boston Museum of Science's *Engineering the Future, Unit 2 Sustainable Cities*
- Participants recruited from Muskegon Heights Public School and Holland New Tech High Schools
- Assessments focused on both knowledge of engineering and the design process and students' attitudes and beliefs

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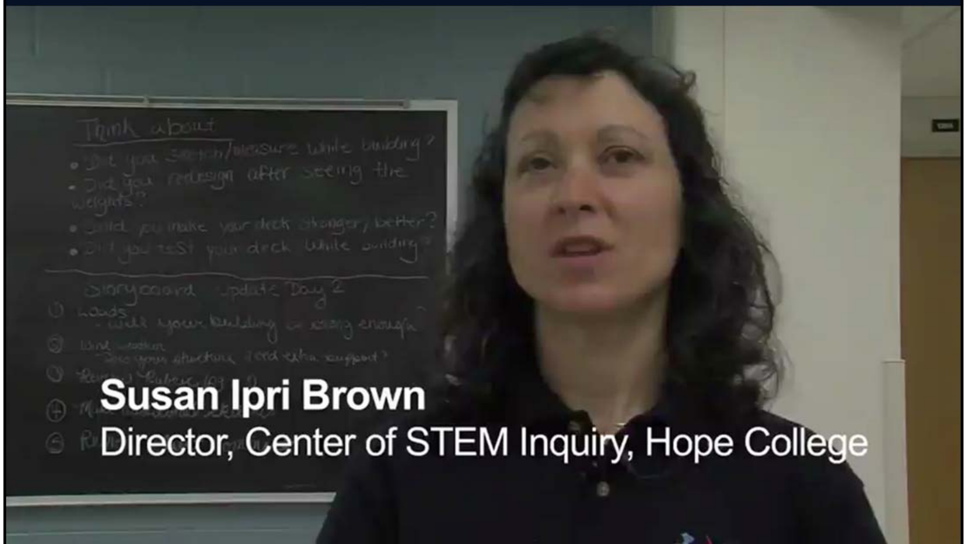

Video Link

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A Teacher's Perspective

- "The power of having a real world context that was centered in their community along with the hands on labs and activities created a strong level of engagement."
- "When I think about the engineering context, I now feel like I have another way to think about my math content."

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A Pre-service Teacher's Perspective

- "I learned that different people are good at different things"
- "It was helpful to see how all the classroom teachers handled the students because they all did it differently. I also really liked the experience of designing lessons because that is a concrete thing I will have to do in my life."

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The Student's Perspective

- … I learned about the process of making a building from start to finish. Starting with looking at an empty lot, and looking at the area around it to find out what needs to be there and what isn't in the area around it. Then learning about urban sprawl and other population difficulties and figuring out the best materials for our building. Lastly we got to design the floor plans of our building and then presented our designs to an engineer…
- (9th grade, male Holland New Tech)

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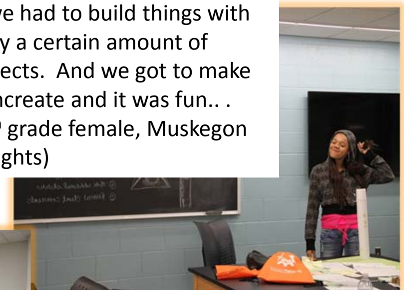
The Students' Perspective

…we had to build things with only a certain amount of objects. And we got to make concreate and it was fun.. . (9^{th} grade female, Muskegon Heights)



We did a lot of fun things that really make you think… (9^{th} grade male, Muskegon Heights)

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The Student's Perspective

Engineering is about creating things, designing things, improving things and breaking things. Engineering is more than just designing, much more. (10^{th} grade male, Holland New Tech)

…we built buildings and designed buildings and that metal can stretch! (9^{th} grade male Muskegon Heights)

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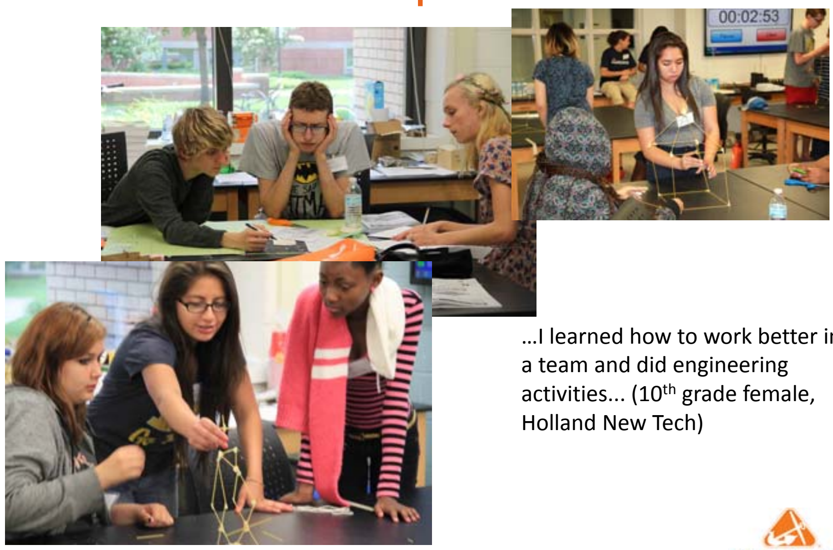
The Student's Perspective



…I learned how to work better in a team and did engineering activities… (10th grade female, Holland New Tech)

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Impact – Quantitative assessment

- Few students (13 of 33, 39%) chose to participate in our follow-up survey distributed several months after the summer academy
- Insufficient quantitative data to assess the effect of participation on student engagement in school

Patterns of Adaptive Learning Scales (Midgley, et al 2000)	Pre	Post	Norms
Academic Efficacy	4.03	4.27	4.15
Avoiding Novelty	2.52	2.42	2.46
Mastery Goal Orientation	4.44	4.23	2.40
Performance Approach Goal Orientation	3.35	3.18	4.20
Performance Avoidance Goal Orientation	3.67	3.27	2.92
Skepticism of the Relevance of School	2.21	2.01	1.95

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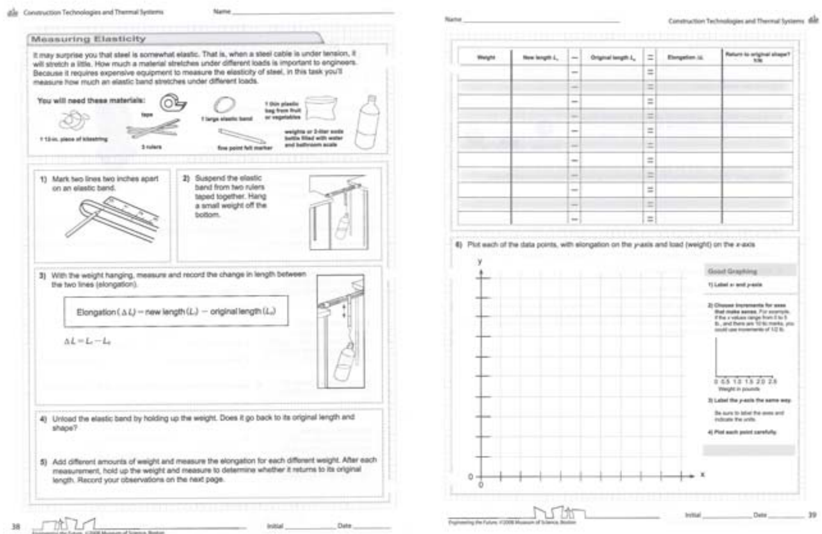
Your turn: Measuring Elasticity


Construction Technologies and Thermal Systems Name ______

Measuring Elasticity

It may surprise you that steel is somewhat elastic. That is, when a steel cable is under tension, it will stretch a little. How much a material stretches under different loads is important to engineers. Because it requires expensive equipment to measure the elasticity of steel, in this task you'll measure how much an elastic band stretches under different loads.

You will need these materials: 1 12-in. piece of kitestring; tape; 2 rulers; 1 large elastic band; fine point felt marker; 1 thin plastic bag from fruit or vegetables; weights or 2-liter soda bottle filled with water and bathroom scale

1) Mark two lines two inches apart on an elastic band.

2) Suspend the elastic band from two rulers taped together. Hang a small weight off the bottom.

3) With the weight hanging, measure and record the change in length between the two lines (elongation).

Elongation (ΔL) = new length (L_n) − original length (L_o)

$\Delta L = L_n - L_o$

4) Unload the elastic band by holding up the weight. Does it go back to its original length and shape?

5) Add different amounts of weight and measure the elongation for each different weight. After each measurement, hold up the weight and measure to determine whether it returns to its original length. Record your observations on the next page.

38 Engineering the Future ©2008 Museum of Science, Boston Initial ______ Date ______

Name ______ Construction Technologies and Thermal Systems

Weight	New length L_n	−	Original length L_o	=	Elongation ΔL	Return to original shape? Y/N
		−		=		
		−		=		
		−		=		
		−		=		
		−		=		
		−		=		
		−		=		
		−		=		
		−		=		
		−		=		
		−		=		

6) Plot each of the data points, with elongation on the y-axis and load (weight) on the x-axis

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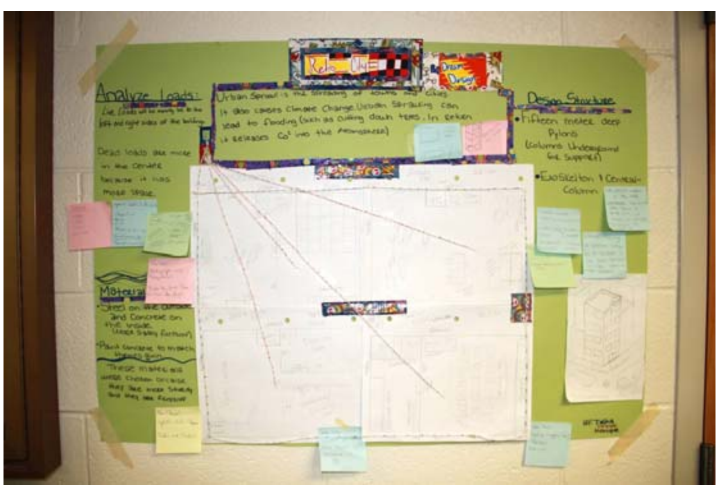
Retro City



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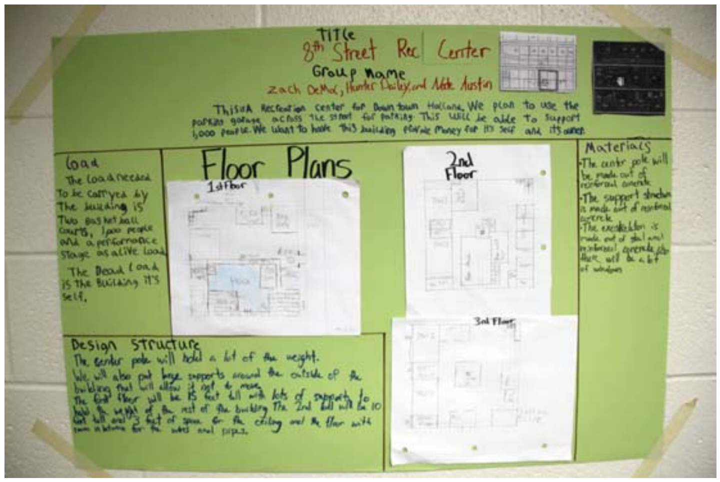
8th Street Rec Center



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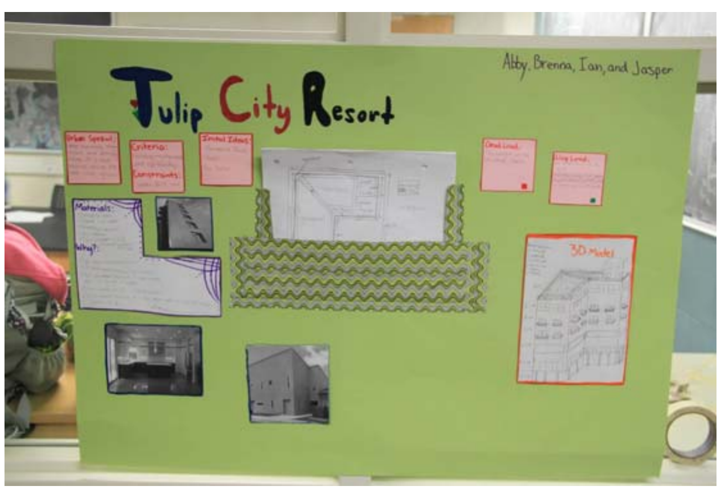
Tulip City Resort



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The Hot Spot

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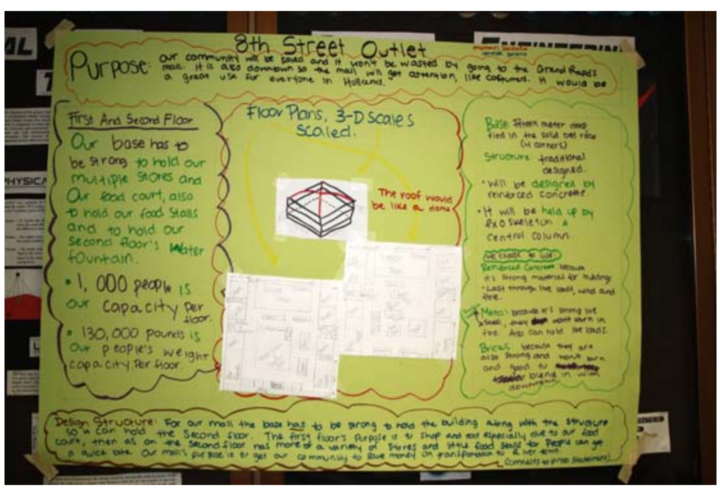
8th Street Outlet



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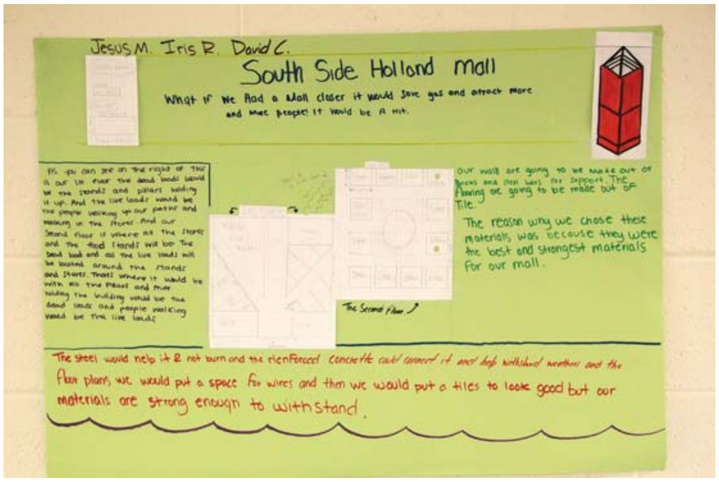
South Side Holland Mall



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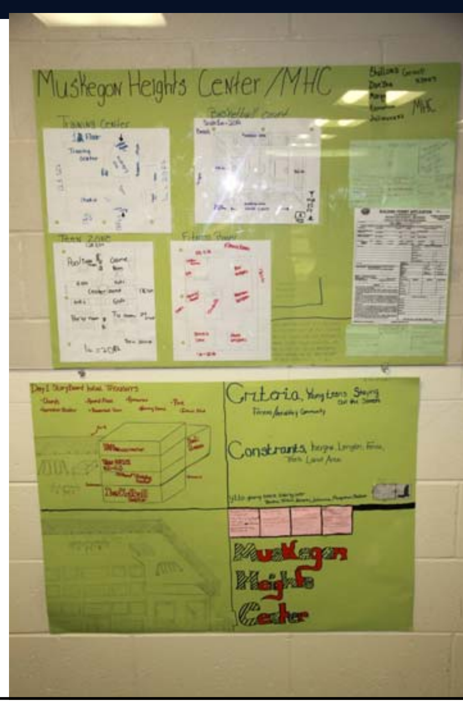
Muskegon Heights Center



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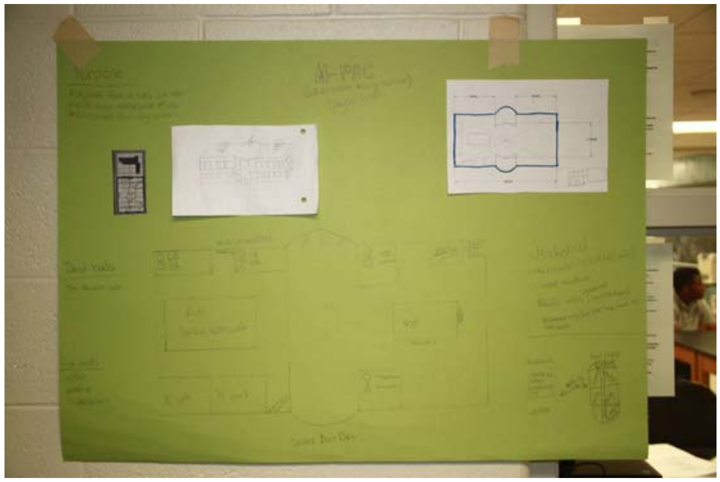
M-Pac



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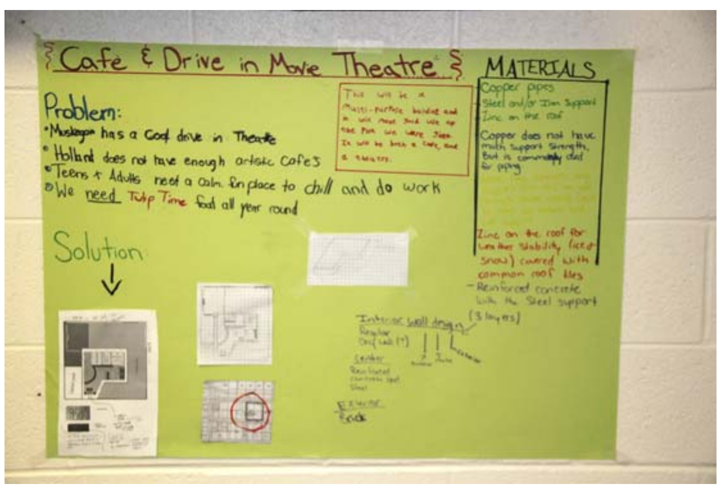
Cafa & Drive In Movie Theatre



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Thank you!

Support NGSS for All Michigan Students

@Sci4MIKids

Have Your Photo Taken Today!
Look for the Volunteers with this Poster

Engineering and Technology Education Resources (1 of 4)

- **A brief list of some of the curriculum programs and internet resources available.**
- **A starting point for you to explore options for getting your students involved in engineering activities**

Elementary

- Engineering is Elementary http://www.mos.org/eie/
- Children's Engineering http://www.childrensengineering.com/index.htm
- Invention-Innovation-Inquiry: Units for Technological Literacy, Grades 5-6 http://www.iteaconnect.org/i3/index.htm
- Project Lead The Way Launch https://www.pltw.org/our-programs/pltw-launch
- Partnerships ImplementingEngineering Education http://www.wpi.edu/Academics/PIEE/Resources/lessons.html
- Curious George – PBS http://www.pbs.org/parents/curiousgeorge/activities/

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Engineering and Technology Education Resources (2 of 4)

Middle School

- Building Math http://walch.com/Building-Math-for-Common-Core-State-Standards-3-Book-Series.html
- Project Lead the Way Gateway https://www.pltw.org/our-programs/pltw-gateway
- Learning by Design™ http://www.cc.gatech.edu/projects/lbd/home.html
- Fetch! – PBS http://www.pbs.org/parents/fetch/index.html

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Engineering and Technology Education Resources (3 of 4)

High School

- Engineering the Future http://www.mos.org/etf/
- Engineering Projects In Community Service-learning (EPICS) – High School http://epics-high.ecn.purdue.edu/
- Project Lead the Way Engineering https://www.pltw.org/our-programs/pltw-engineering
- Design Squad PBS http://pbskids.org/designsquad/parentseducators/index.html
- Rube Goldberg Machine Contests http://www.anl.gov/Careers/Education/rube/

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Engineering and Technology Education Resources (4 of 4)

More Information/Resources

- National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy (TEL) Assessment http://nces.ed.gov/nationsreportcard/tel/moreabout.aspx#framework
- American Society for Engineering Education http://teachers.egfi-k12.org/
- National Science Digital Library https://nsdl.oercommons.org/
- National Center for Technological Literacy http://www.mos.org/nctl/
- International Technology and Engineering Educators Association http://www.iteaconnect.org/
- Teacher's Domain-Engineering http://www.teachersdomain.org/sci/engin/index.html
- PBS Learning Media: Engineering Design http://www.pbslearningmedia.org/search/?q=&selected_facets=supplemental_curriculum_hierarchy_nodes%3A270&selected_facets=
- Engineering in K-12 Education: Understanding the Status and Improving the Prospects http://www.nap.edu/catalog.php?record_id=12635
- NASA Endeavor Certificate in STEM Education http://www.us-satellite.net/endeavor/index.cfm

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Note: The second author, W. Harwood published a version of this model in the January 2004 issue of The Science Teacher. An Activity Model for Scientific Inquiry, pp. 44 – 46.

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