Cutting-Edge Research: Math Infusion into Engineering/Technology Education

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Mathematics across the Middle School Math, Science, and Technology Curriculum (MSTP)

- Goal: To improve student mathematics learning and performance by embedding math in science and technology education instruction
- A five-year NSF project, working in 10 high need districts in Long Island, where 74% of students failed to meet state 8th grade mathematics standards

Why infuse math into STEM?

- According to The National Council of Teachers of Mathematics (NCTM, 2002) "students should connect math to their daily lives, and to situations from science, social science, and commerce."
- Integrating math and science/technology enables students to:
  - Develop a common core of knowledge
  - Form deeper understanding of science
  - Envision a larger picture
  - Find relevance in the curriculum
  - Make connections among central concepts

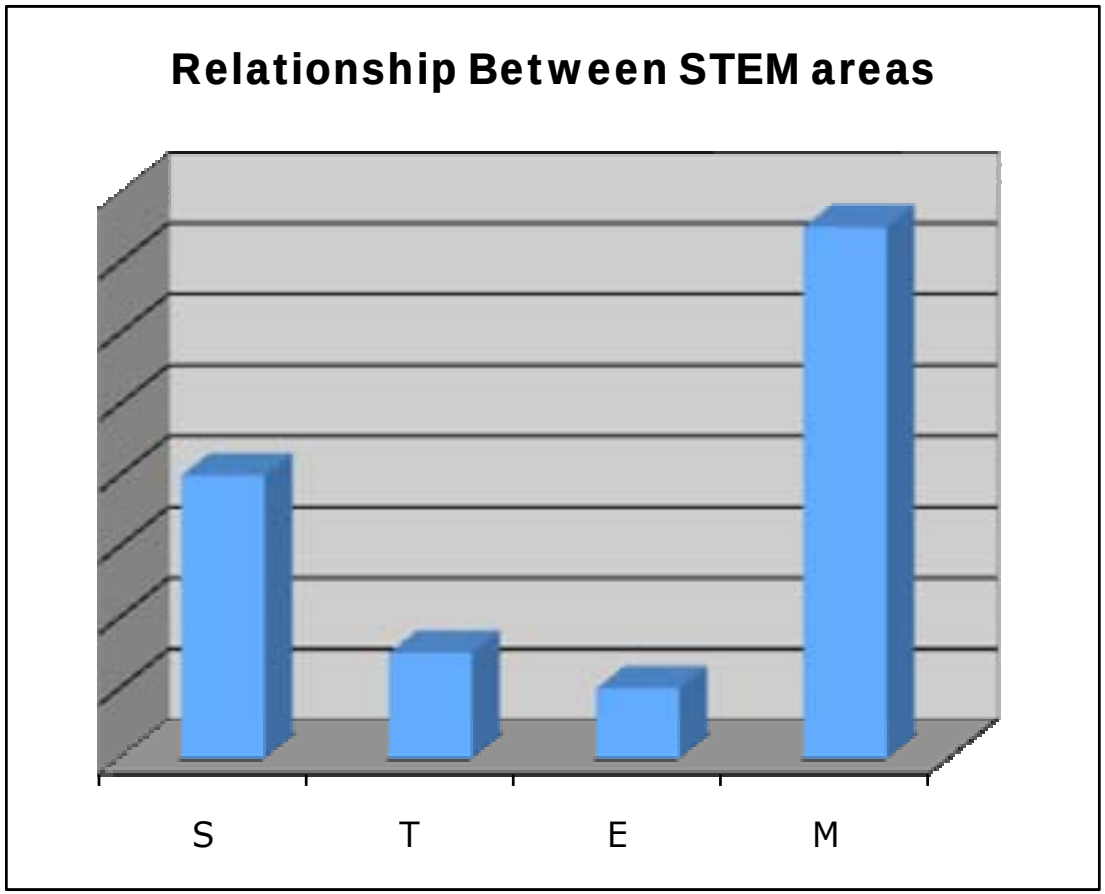
    (Czerniak, Weber, Sandmann, & Ahem, 1999)

Key Elements of the Math Infusion in STEM Model

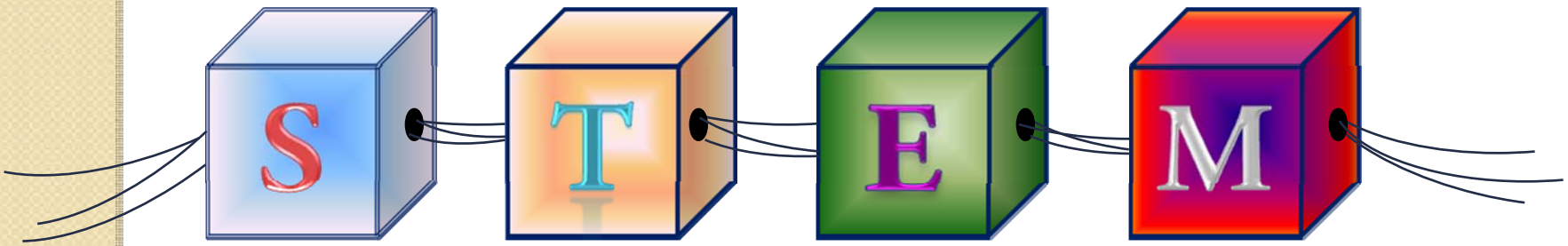
- Science and Technology remain separate classes with math "infused into the content"
- Criteria for selection of math for infusion
  - Math must be meaningful (important math)
  - Math must be relevant for Science or TE
  - Math must be a content that students find difficult
  - Math must be taught in a inquiry-based way

The Traditional Approach: STEM SILOS

- Math, Science and Technology, Engineering stand apart
- No Standards link them
- Different Language used: manipulated/ responding vs. independent/ dependent

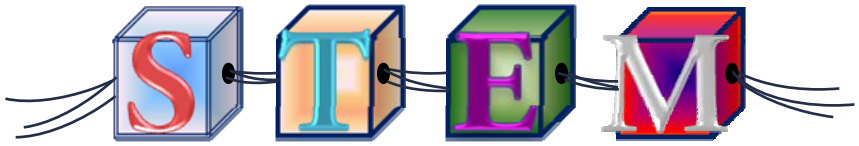


Interconnected STEM with Infusion Threads



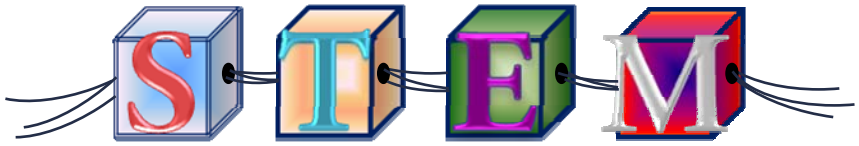
Starting Point for Math Infusion: Teacher skills and knowledge

- Teachers must have adequate math content knowledge
- Teachers must have adequate pedagogy skills to teach the math in a constructivist way
- Teachers must value infusion of math and be able to support student math learning

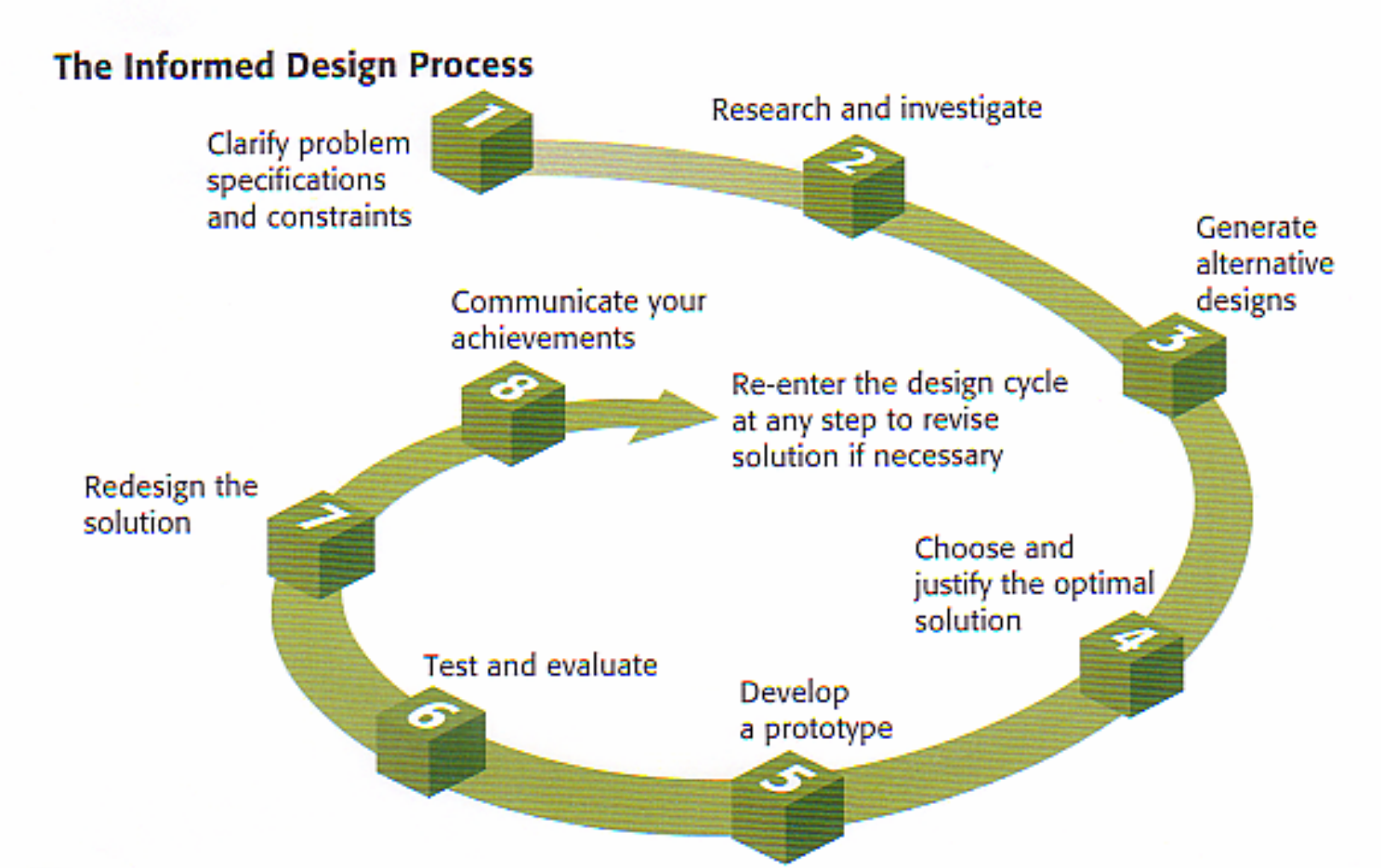


Informed Design

- Informed Design is a pedagogical approach to design developed and validated through several NSF-funded Projects conducted by the Hofstra CTL
- Informed design enables students to enhance their knowledge and skill base by engaging in Knowledge and Skill Builders (KSBs) before proposing solutions



Informed Design

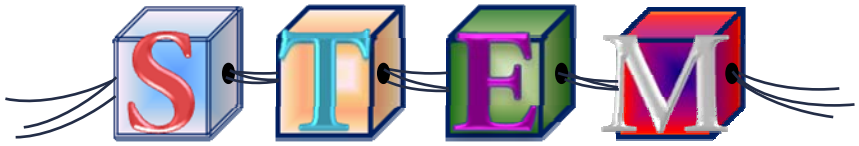


Knowledge and Skill Builders (KSB's)

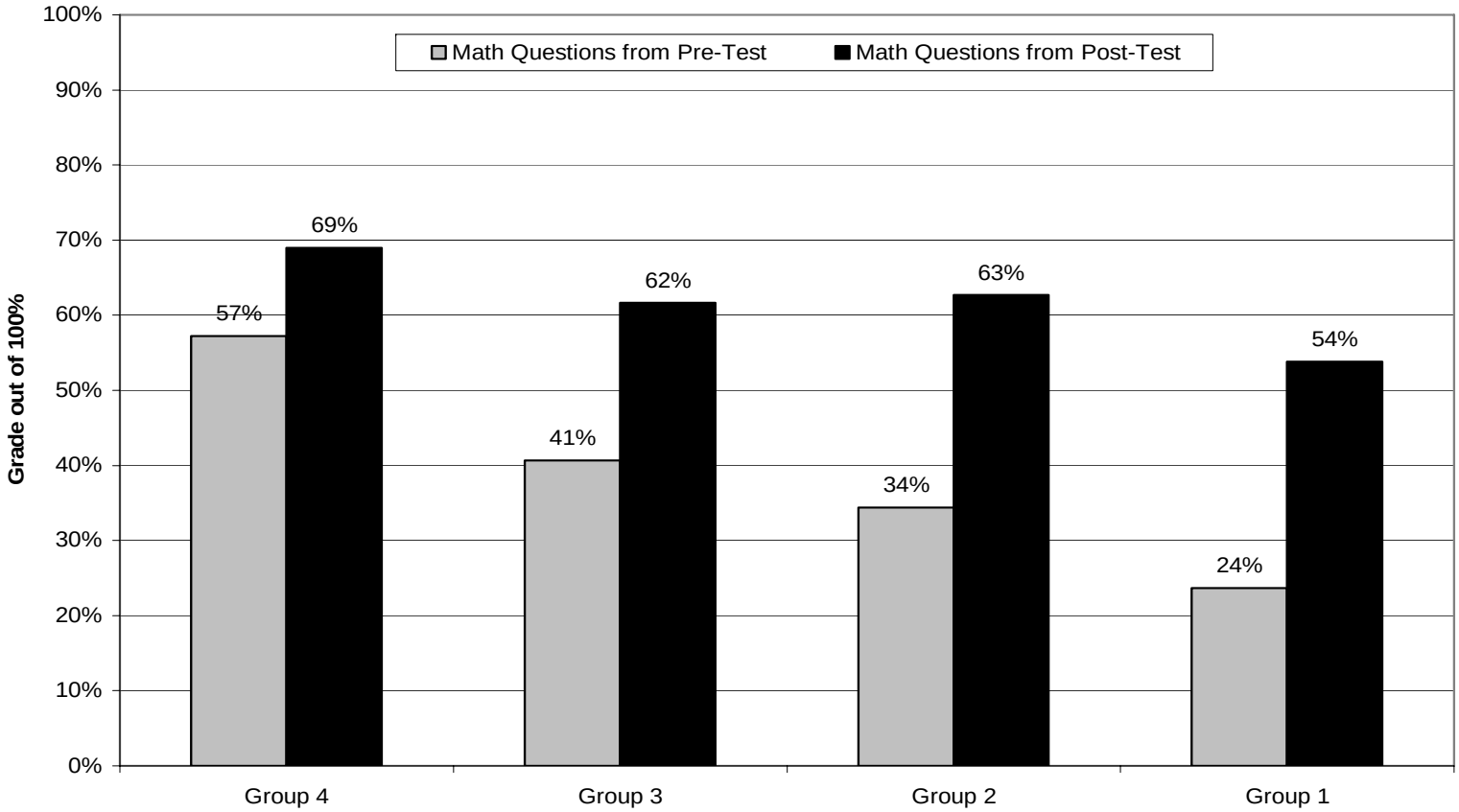
- A key idea in the informed design process is to have scaffolding math, science and technology activities that "inform" student knowledge before the design is attempted.
  - The process is very consistent with the "backwards design" process advocated by Wiggin and McTighe
- KSBs are short, focused JIT guided research-based activities designed to help students optimize variables that affect design performance
- In this way, students reach design solutions informed by prior knowledge, as opposed to engaging in trial-and-error problem solving where conceptual closure is often not attained

Math Infusion in Engineering/Technology Education (ETE)

- Multi-year effort starting in 2004
- Use of Informed Design-engineering design with requiring use of core (M and S) knowledge.
- Providing Knowledge and Skill Builder (KSB) activities that use core M & S necessary for design solution.



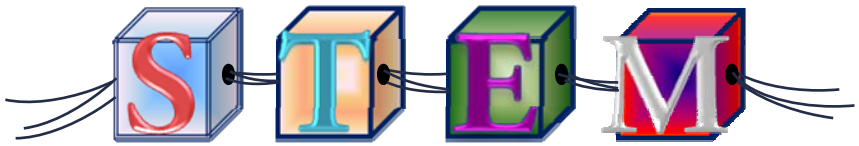
Drying by Design



- Dehydrate 250 grams of apple slices as efficiently as possible with area and time constraints.
- Math: area, perimeter, ratio, percent, linear, non-linear

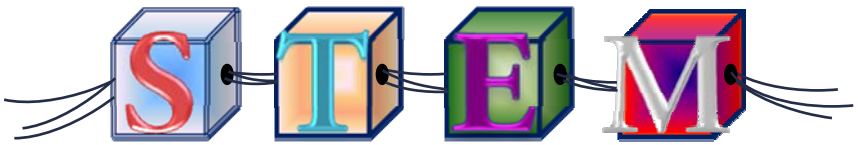
MSTP Approach to Math Infusion

- Curriculum revision and alignment
- Operationalizing the Model through a lesson template
- Establish STEM Learning Communities (PD)
- Proof of concept studies
  - Teacher learning through STEM Learning Communities
    - Teacher understanding and use of the approach
  - Student attitude and content knowledge change



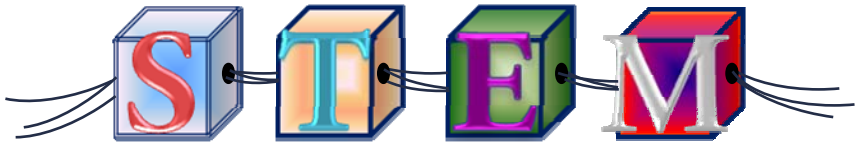
Operationalizing the Math Infusion Model

- A "curriculum template" was developed to guide teachers in selecting content, pedagogy and assessments for math-infusion
  - Used and pilot tested by numerous classroom teachers
  - Can be used to assess teacher use and application of the model



Delivery through STEM Learning Communities PD

- A month-long PD activity known as the "A-B Workshop"
- Brings together STEM Higher Education faculty partner with middle school STEM teachers in professional learning communities

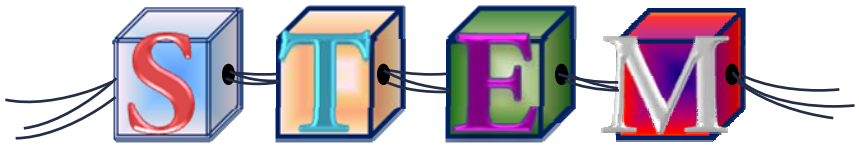


STEM Learning Communities PD

- Teachers develop a 2-3 day lesson during 'A' component
  - Collaboration with peers in learning communities, both within and across content areas to ensure that math infusion is "optimized"
  - Develop diagnostic or 'pre assessments', formative and/or summative 'post assessments' and scoring rubrics
- Teachers implement the lesson in their own classroom during the next two weeks
  - Score all student work and select three samples representing varied levels of student performance (low, average, high)
- Teachers revise the lesson during 'B' component
  - Peer review and lesson revision are the crux of the B workshop

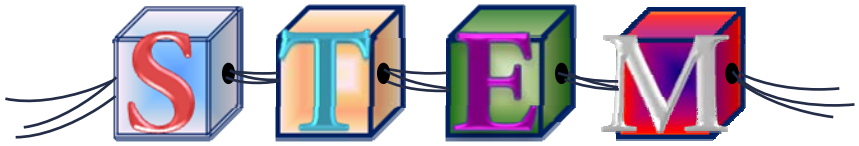
STEM Learning Community: Highlights

- During the 2006 – 2007 school year over 150 math, science and technology teachers attended 36 hours of infusion related A/B professional development workshops
- Over 701 lessons developed (373 math, 266 science, and 62 technology lessons)
- Over 90% of teachers:
  - Reported the A/B workshops were useful or very useful
  - Used the MSTP lesson template to create an enhanced math and/or math infused lesson
  - Reported they would use the MSTP lesson they created again

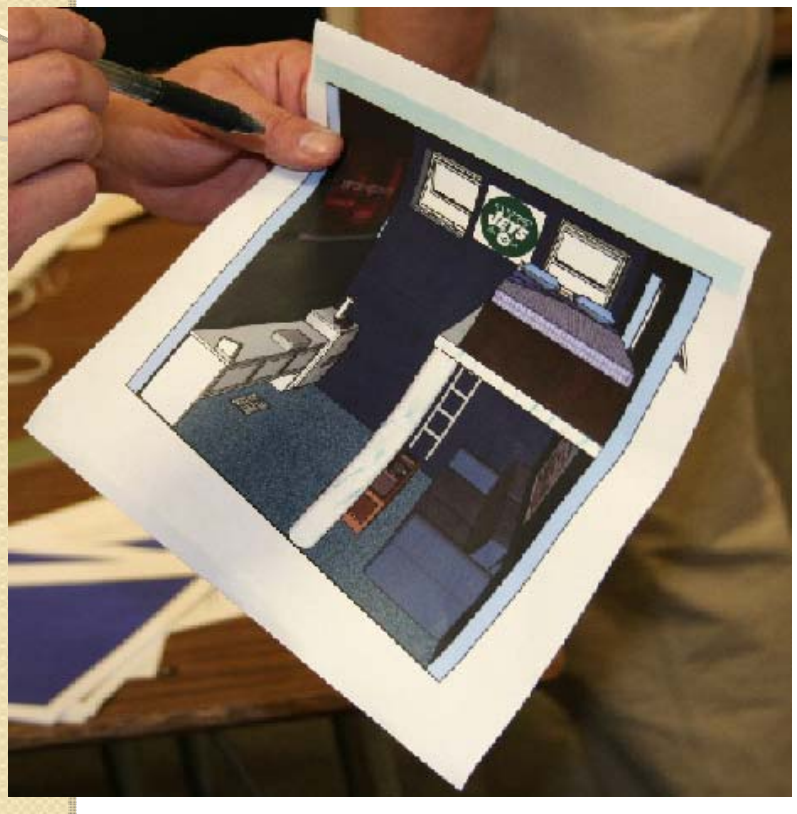


MSTP Bedroom Design

- Hybrid modeling
  - Virtual and Physical Modeling
- Use of Google Sketch-Up
- Math includes area, perimeter, percent and ratio
- Physical modeling can be completed in computer lab or classroom.



Hybrid Modeling



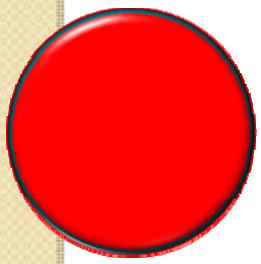
- *Integrates screen-based 3-D simulation and real-world physical modeling*

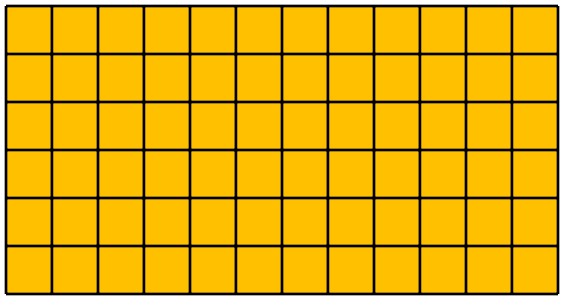
Infusing Core Math Ideas

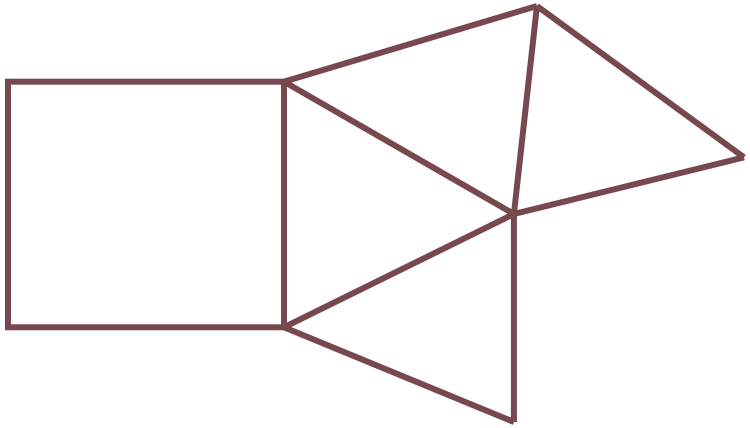
- YOUR CHALLENGE:
  - You are moving into a new home. You and your team mates have a challenge to design an optimally furnished bedroom. It can be a dream bedroom. You have a budget of $27,500 to design it with as a rectangular bedroom with minimum dimensions of 120 square feet. However, if you wish to be really creative and design a non-rectangular bedroom of 120 square feet minimum, the budget increases to $30,000. You will construct virtual and actual scale models of your bedroom, with furnishings.

Infusing Core Disciplinary Concepts into Bedroom Design

- Knowledge and Skill Builder 1: Geometric Shapes
- Knowledge and Skill Builder 2: Ratio and Proportion
- Knowledge and Skill Builder 3: Creating and Folding Nets
- Knowledge and Skill Builder 4. Aesthetics
- Knowledge and Skill Builder 5. Pricing Information: Creating Formulas in Spread Sheets







Knowledge and Skill Builder: Geometric Shapes

It is important to understand different geometric shapes so you can use them in your design. In this KSB you will draw different geometric shapes and determine their areas and perimeters. Using 24 square tiles, arrange them to make rectangles that have an area of 24 square units and have whole number dimensions. Then draw them on the grid provided.

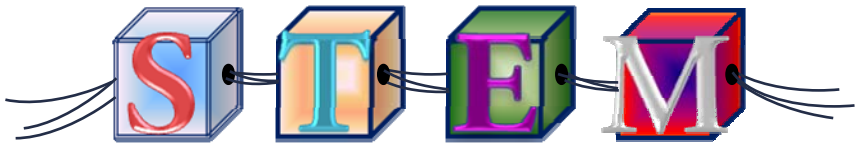
Length in units	Width in units	Area in square units	Perimeter in units

1. From a math perspective, what are the factors of 24? Indicate next to each figure its perimeter. (Show the whole numbers used for the dimensions.)
2. How do you know you have found all rectangles meeting the requirements ?
3. What is the relationship between a rectangle's dimensions and its area?
4. What is the relationship between a rectangle's dimensions and perimeter?
5. Which rectangle with an area of 24 square units has the greatest perimeter.
6. Which rectangle with an area of 24 square units has the least perimeter.
7. How can the cost of wall construction and wall covering be minimized?


malanga's room
dude on bed

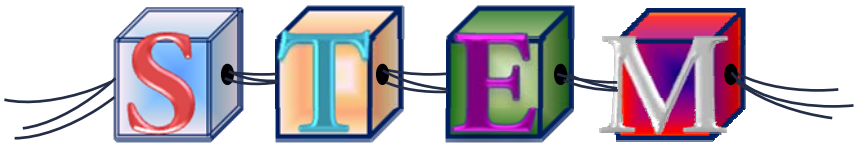
Proof of Concept Study: Research Procedures

1. Student survey data (math content knowledge and attitudes toward math) are collected before and after participating in bedroom design
   - Content questions adapted from New York State math standardized tests (multiple choice and open ended)
   - Attitudinal questions were on Likert-type statements about liking of and use of math.
2. Observations of classroom lessons
3. Teacher weekly online feedback survey
4. Examination of student work, including KSBs
5. Teacher focus group and/or interviews following lesson.

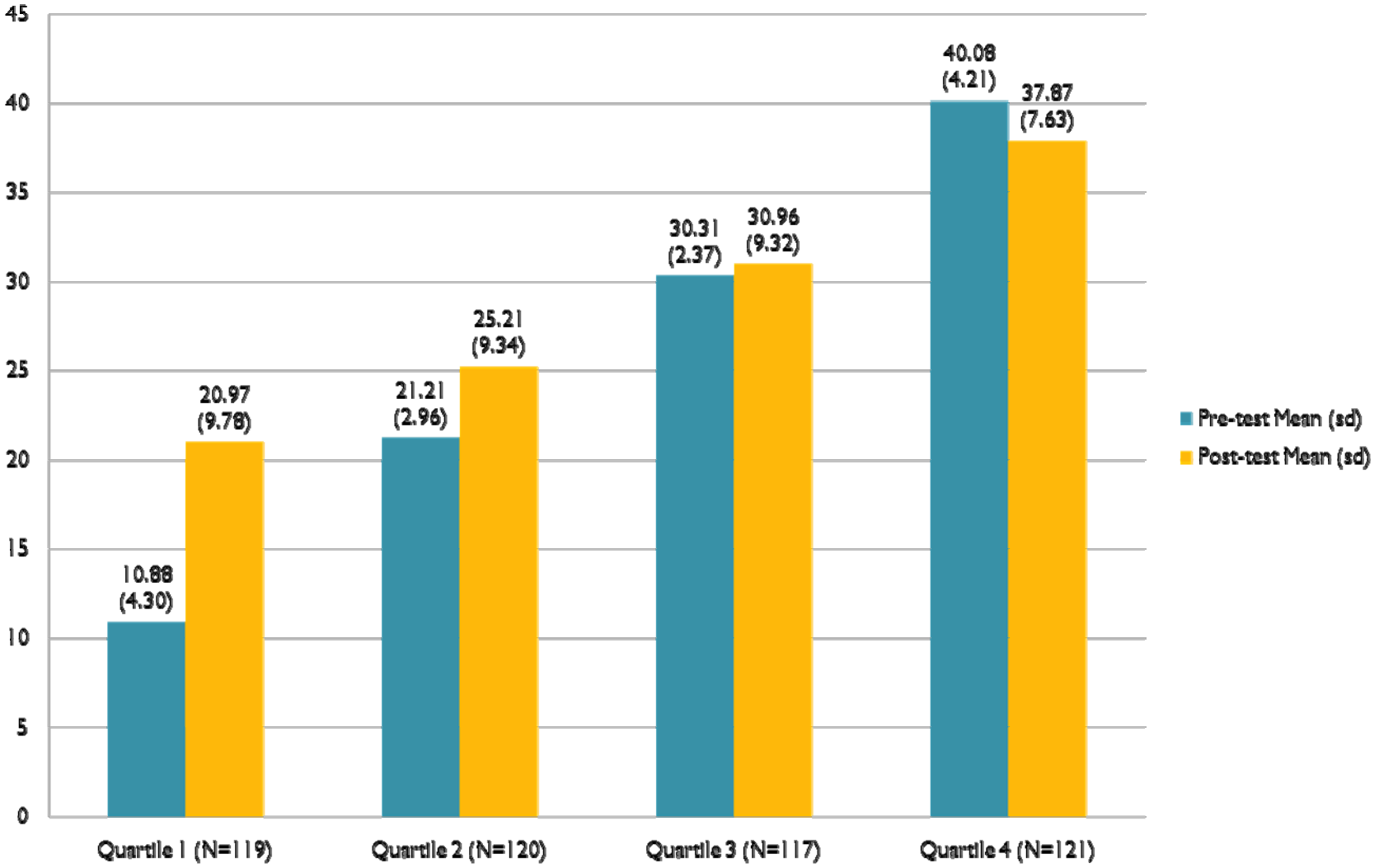


Some Research Findings: Fall 2007

- Student responses were compared using a matched paired t-test.
- A statistically significant difference was found: $t(58) = 3.397$, $p = .001$ between the before and after administration.
- The content knowledge mean before the lesson was 6.51 (standard deviation 3.46) and after the lesson was 7.75 (standard deviation 3.77)
  - Scores could range from 0-15.

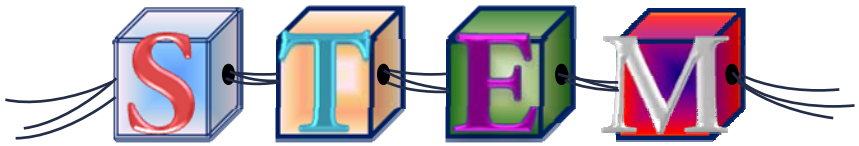


Science Infusion Students: Mean Performance on pre and post test scores by quartile group



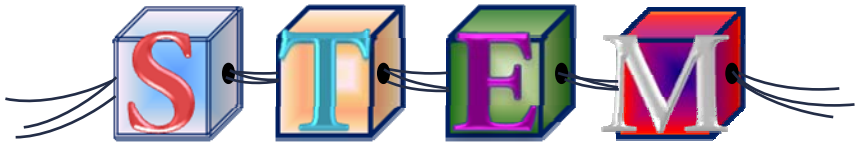
Elements of Success

- Infusion enhanced teacher mathematical content and pedagogical knowledge
- The development of a feasible model of math infusion into science and technology classes
- Study demonstrated math can be infused into science and technology
- Math introduced taught in-context (fit naturally within technology topics)
- Students expressed few of the of the frustrations anticipated with math infusion



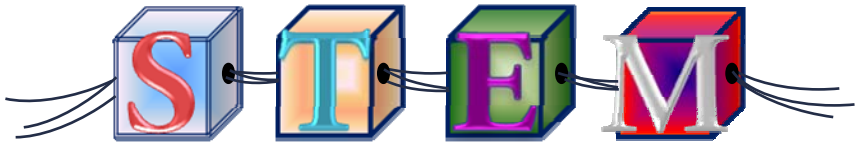
Math Infusion - Challenges

- Teacher Pedagogical Content Knowledge
- Assessment Questions (did they really assess the infused math?)
- Scoring Rubric for open-ended questions
- Consistency of the teaching the bedroom design unit between teachers

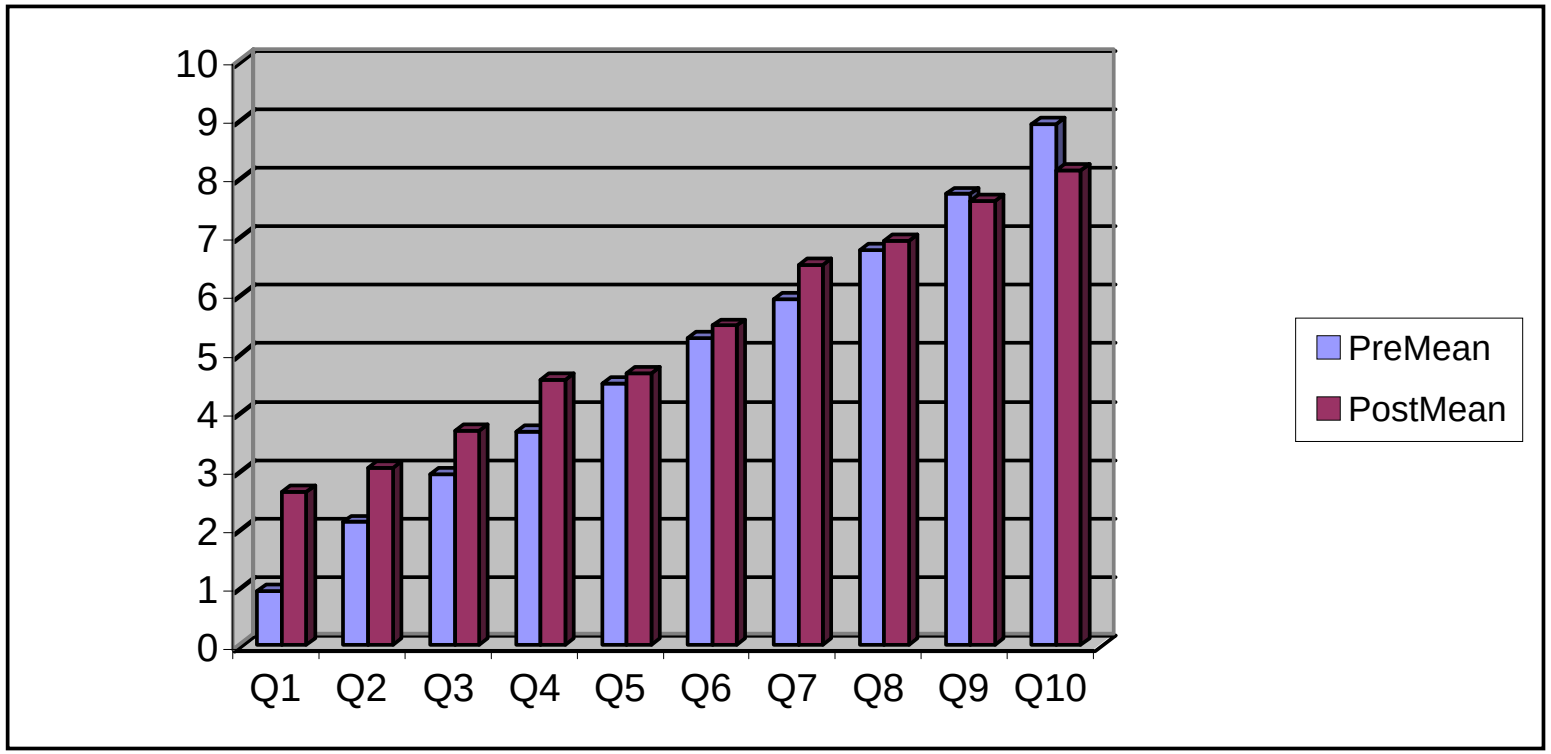


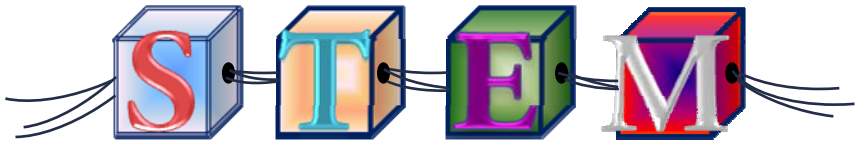
Math Infusion in ETE

- 15 teachers implementing Hybrid Model in Fall 2008; 8 days of Professional Development
- 20 teachers implementing Hybrid Model in Spring 2009; 3 hours of Professional Development



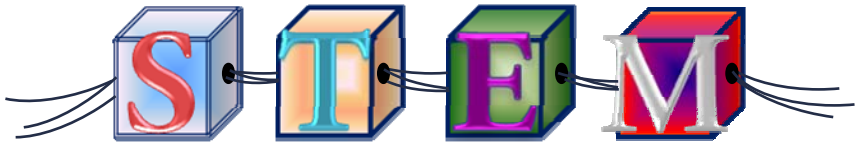
FALL 2009 Pre/Post Results Beta version





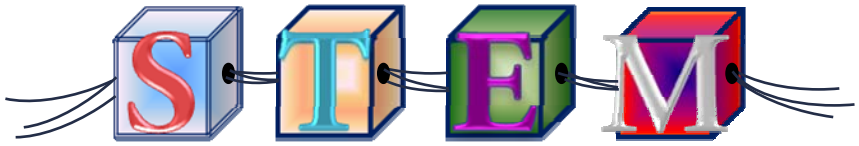
Going Forward with Hofstra's Research Agenda

- Research on STEM Learning Communities
- Research on Math Infusion in Science and ETE
- Virtual and Physical Modeling (Hybrid Modeling)
- STEM Symposium



What Can School Districts Do Now?

- STEM Teaching Areas in proximity to one another
- Common planning time (prep)
- Professional Development re math infusion (grade level dependent)
- Use ETE to support math infusion with proper training of teachers
- Newsletter featuring STEM connectiveness



For further information contact:

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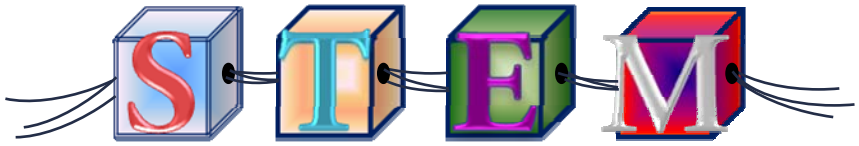
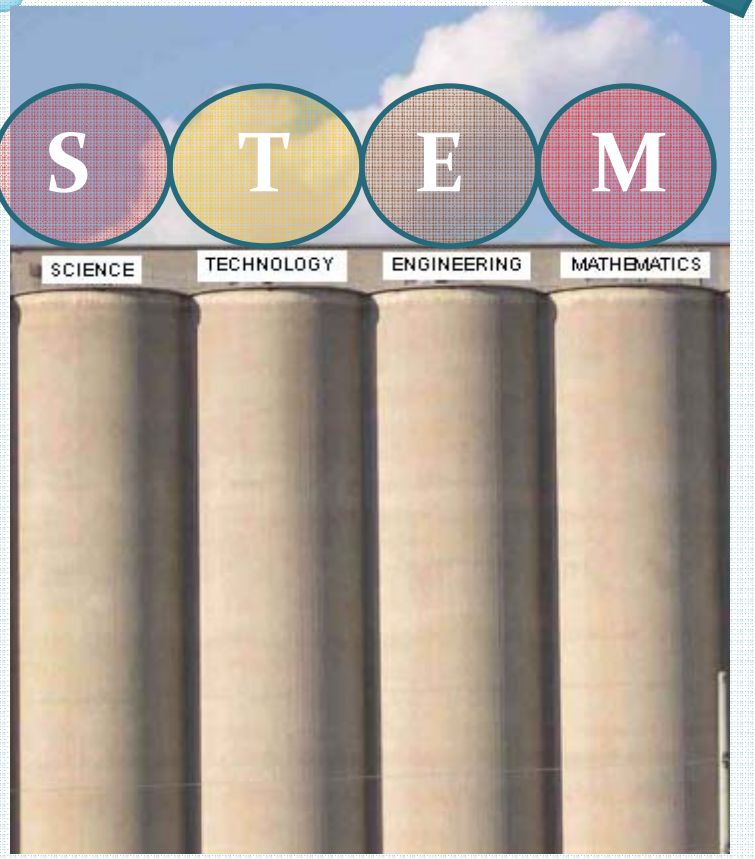
Hofstra Center for Technological Literacy

www. hofstra.edu/CTL



The New Paradigm…..

- **Transition from**



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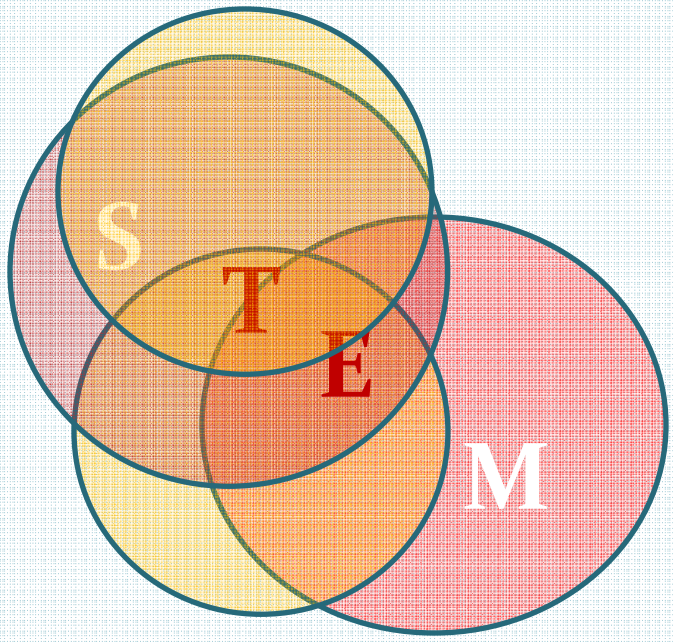

With Technology and Engineering as the Connectors