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Using Engineering to Address the Common Core Standards: A Four Week Workshop (Curriculum Exchange)

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Using Engineering Content to Meet the Common Core Standards:
Examples from a Workshop for Middle School STEM

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What's Available at the Station: This collaboration includes Vigo County School Corporation (Terre Haute, IN) and Rose-Hulman Institute of Technology's PRISM Project (http://rose-prism.org). A package of materials provides (1) an overview for the integrated curriculum approach, (2) synopses of the three workshops given by engineering professors, and (3) examples of lessons – based on engineering concepts – developed by 6^{th} – 8^{th} grade teachers. Visitors to the exhibit table will be greeted by members of the PRISM team, a middle school teacher, and an engineering professor, eager to answer questions and share insights on how implementation progressed during the academic year.

The curriculum demonstrates how interaction among collegiate engineering instructors, pre-collegiate STEM teachers, and gifted/talented students resulted in innovative models, methods, and materials for integrating engineering concepts and practices into a standards-driven curriculum and pedagogy.

Engineering Professors and Professional Development Workshops: Our multi-component treatment uses engineering activities to address the Indiana State Academic Standards by designing a vertical and horizontal curriculum for 6^{th} – 8^{th} grade, to be used within a large, metropolitan school district. The summer of 2013 event was the first in a series of three (2013 – 2016) and was funded through a $450,000 Math / Science Partnership Grant, made through the Indiana Department of Education.

WEEK ONE: 3 – 6 June, 2013	
The Nanoscale	Sessions focused on how nanotechnology has impacted our society and how engineers have learned to explore the world at the nanoscale. Teachers participated in hands-on activities to understand exactly how small the nanoscale is, explored how surface area changes at the nanoscale, and work in teams to develop futuristic applications of nanotechnology.
WEEK TWO: 10 – 13 June, 2013	
Design a Passive Solar House	The Solar Structures unit explored how the power of the sun can be harnessed to heat and cool a building. Teachers worked in teams of "engineers" to design and build their own solar houses out of everyday items. They tested their solar house, evaluated their results, and presented to the class.
WEEK THREE: 17 – 20 June, 2013	
Gravity Cruiser	Teams designed and constructed a vehicle powered by gravity. Concepts explored include potential and kinetic energy, friction, inertia, momentum, diameter, circumference, measurement, graphing, and constructing a prototype.
WEEK FOUR: 12 – 15 August, 2013	
Consolidation	Teachers worked collaboratively and with curricula development coaches to finalize lessons. Emphasis was placed on reviewing the vertical integration of learning goals among disciplines and grade levels. Participants also developed a range of assessment materials that reflect learning within the Common Core State Standards.

Students Provide Beta Testing and Teachers Receive Two Levels of Feedback: Participating teachers spent a portion of their day crafting and field-testing small learning units for a group of 350 gifted-and-talented (G/T) students attending co-located summer enrichment programs that mirrored the learning activities being used in the teacher training. These trial-runs help teachers to make iterative improvements in their planned activities. In addition to student responses, the middle school teachers were able to work on aspects of delivery (pedagogy and methods) in a real-time environment, under the mentoring of master teachers from the G/T programs.

Designing a Solar House – Investigating Passive Solar Energy

Grade Level: 6 – 8
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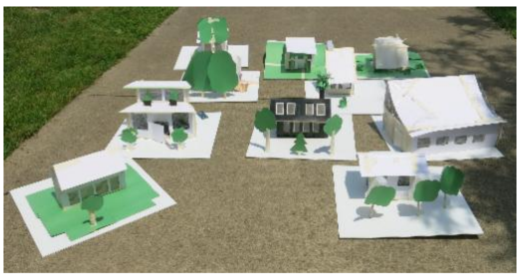
Indiana State Academic Standards: (1) Use models to enrich understanding of complex systems. (2) Practice iterative design through planning, prototyping, testing, and refining an artifact. (3) Learn methods of data collection, analysis, and representation. (4) Practice collaboration and communication skills within a project-based learning unit.

Activities Summary: This learning unit explores how the sun can heat and cool a building. Students work in teams to design and build a model solar house that can sustain an acceptable temperature range out of commonly available materials. They then test their structures, evaluate their results, and refine their designs. A poster presentation may be used to consolidate learning gains.



ACTIVITY

1. Defining the Problem– As a group discussion session, students share their current knowledge about renewable energy and environmental issues. As a refinement, students might make a list of factors to consider in using passive solar energy for regulating the temperature of a structure.

As a class, look at these (or comparable videos) as a context for the design project.

- https://www.youtube.com/watch?v=Prx6rJPZFIE
- https://www.youtube.com/watch?v=N1hos0futH0

Students are given a sheet containing the "challenge problem": design a model home of a defined size from a set of materials. The goal is to sustain an acceptable temperature range (as determined by the students) in the model, both in the direct sun and in the deep shade.

2. Carrying Out Investigations and Planning – Using a series of hands-on investigations, students explore principles of energy transfer, thermal properties of materials, mass and thermal storage, angles of the sun, and direct / indirect gain systems. These activities are interleaved with brainstorming and planning on paper.

3. Distribute Available Materials – Students make selections from a range of available items, guided by their notional design and their understanding of thermal properties of materials. To emphasize optimization, materials might have prices, and teams might be given budget limitations.

4. Construct the Model – Teams build their prototypes, guided by their work in all three previous steps. Mid-course corrections are to be expected; many stem from the pragmatics of not being able to realistically construct an overly complex approach.

5. Testing: Data Collection and Analysis – Students test by taking models outdoors and collecting temperature data, based on direct sun and deep shade. By taking thermometer readings at defined intervals for a set period of time in these two conditions, the class can compare the efficacy of their differing designs.

6. Constructing Explanations from Evidence: Each team presents its model (including their approach, use of materials, and best features). Then each team presents its data. The class – as a whole – discusses each design relative to its effectiveness, as determined by the data. After comparing results from all models, the class speculates on what elements in the construction most influenced fluctuations in temperatures.

7. Systemic Thinking, Trade-Offs, and Conceptual Re-design: Each team reconsiders its structure, based on the general principles for efficacy that emerged from the group critique conducted in Step 6. In addition, the groups could be asked – in this final iteration – to give some thought to larger contextual issues, such as livability, aesthetic qualities, environmental impacts, and marketability. Each group makes a list of what modifications they would make to the original; they also provide at least one rationale for each change. Another team serves as peer-reviewers for this design revision, ensuring that adjustments for individual parts are explained in terms of how they relate to the whole. If time allows, each group should be allowed to create and test their redesign.

8. Presentation – If time permits, students consolidate their design and data results into a poster for the local homebuilders' showcase.