Makerspace & Curriculum
The Overlap of Standards and Curriculum, K-12

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iSTEM Educational Assistant // Adjunct Professor // Grants

9-11am  ●  Rutgers  ●  2/26/2015
School of Engineering
Biomedical Engineering, Civil Engineering, Computer Engineering, Electrical Engineering, Mechanical Engineering, Engineering Science

Department of Technological Studies
Technology & Engineering Ed (K-12)
Elementary iSTEM Ed (Dual Cert w Specialization)
Secondary iSTEM Ed MAT (this Fall)

Center
TSA State Office
Engineering by Design (EbD) Grant
K-12 Consultancy, Trainers, Grants
K-12 Academic Partnerships
CURRICULUM

• Curriculum is integrative, students experience the content areas as being interrelated, just like they are in 21st Century Life and Careers

• Literacy developed through thematic, real-world Design Challenges that have relevance to students’ lives

• Hands on; use of tool & machines, materials processing
INSTRUCTION

• Instruction is student driven and teacher facilitated; using the Engineering Design Process as a structure for authentic teaching and learning

• Instruction is interdisciplinary

• Uses Science & Engineering Practices as Necessary

• Risk taking is encouraged
ASSESSMENT

• Heavy Formative Assessment, Less Summative

• Engineering Notebooks as a primary assessment source

• Mistakes are valued treated as opportunities for students to learn from and track personal growth

• Students assess themselves and one another in and outside of the traditional classroom environment
"the application of technological/engineering design based pedagogical approaches to intentionally teach content and practices of science and mathematics education concurrently with content and practices of technology/engineering education. Integrative STEM education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels" (Dr. Mark Sanders & Dr. John Wells, 2012)
“e” - Engineering Design Process
Two similar models, same gist!
Engineering Design Process Loop

Getting to Know the Problem
- Identify
- Research

Brainstorm
- Generate Multiple Solutions
- Sketches

Developing a Solution
- Pick Best Solution
- Rationale
- Sketch

Prototype/Build

Test and Evaluate

Redesign
What is a Problem?

- Problems are a relative to people’s wants and needs
- Problems have stakeholders and audiences
- Problems can be seen as opportunities to invent something new or innovate existing things
- Problems are open-ended, with more than one right answer, however…
- Problems are tied to specific constraints and criteria for what constitutes a viable solution
Definition of a “Solution”

Solutions, be they **products** or **systems**, large or small, simple or complex, custom or universal - fall on a *continuum*.

On one end of the continuum, the products and systems are **tangible** or **physical**…
More types of “Solutions”

On the other end of the continuum would be non-physical or abstract

These solutions can be digital, clerical, graphic, intellectual, event-based, web-based, organizational, etc…
# DESIGN VS. INQUIRY

## Definition
- **INQUIRY**: Seeking knowledge
- **ENGINEERING DESIGN**: Devising a system, component or process to meet desired needs

## Objective
- **INQUIRY**: Truth
- **ENGINEERING DESIGN**: Extending human capabilities

## Methodology
- **INQUIRY**: Discovery/Exploration (Scientific method)
- **ENGINEERING DESIGN**: Invention & Innovation (Engineering Design Process)

## Question Asked (example)
- **INQUIRY**: What is water made from?
- **ENGINEERING DESIGN**: How can water be moved uphill?

## Answer to Question Asked
- **INQUIRY**: Usually one answer: \(\text{H}_2\text{O}\)
- **ENGINEERING DESIGN**: Many possible answers: Buckets, pumps, water wheels, augers

## Something to Think About
- **INQUIRY**: Can you do INQUIRY without design? Answer: Yes
- **ENGINEERING DESIGN**: Can you do ENGINEERING DESIGN without inquiry? Answer: No

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Table Created by: Professor Vincent Walencik, Montclair State University, 2013
Step 1: Identify the Problem

Step 2: Frame the Design Brief

Step 3: Research & Brainstorming

Step 4: Generate Alternate Solutions

Step 5: Chosen Solution & Rationale

Step 6: Developmental Work

Step 7: Production (*product, system, device, event*)

Step 8: Testing & Evaluation

**Step 9: Redesign & Reflect**

Step 10: Communicate (*document, present*)
Bloom’s (new?) Cognitive Pyramid

- **Creating**
- **Evaluating**
- **Analyzing**
- **Applying**
- **Understanding**
- **Remembering**

- Brainstorm
- Invent
- Innovate
- Imagine
- Design
- Prototype
- Model
- Redesign
- Draw
NGSS

• Engineering as 4th Core Discipline
• Standards cite integration for Common Core
• Engineering Design Challenges in each grade level, K-12
### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>Life Science</th>
<th>Physical Science</th>
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<tbody>
<tr>
<td><strong>LS1:</strong> From Molecules to Organisms: Structures and Processes</td>
<td><strong>PS1:</strong> Matter and Its Interactions</td>
</tr>
<tr>
<td><strong>LS2:</strong> Ecosystems: Interactions, Energy, and Dynamics</td>
<td><strong>PS2:</strong> Motion and Stability: Forces and Interactions</td>
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<td><strong>LS3:</strong> Heredity: Inheritance and Variation of Traits</td>
<td><strong>PS3:</strong> Energy</td>
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<td><strong>LS4:</strong> Biological Evolution: Unity and Diversity</td>
<td><strong>PS4:</strong> Waves and Their Applications in Technologies for Information Transfer</td>
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<thead>
<tr>
<th>Earth &amp; Space Science</th>
<th>Engineering &amp; Technology</th>
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<tbody>
<tr>
<td><strong>ESS1:</strong> Earth’s Place in the Universe</td>
<td><strong>ETS1:</strong> Engineering Design</td>
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<tr>
<td><strong>ESS2:</strong> Earth’s Systems</td>
<td><strong>ETS2:</strong> Links Among Engineering, Technology, Science, and Society</td>
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<td><strong>ESS3:</strong> Earth and Human Activity</td>
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</tbody>
</table>
Common Core for Math & LAL on Every Page!
Scientific and Engineering Practices

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
NGSS DESIGN LOOP
Beginning in Grade K

- In a Design Challenge, students would use practices of Science & Engineering at different steps as they develop, test and optimize (redesign) solutions.

- Evidence Based Writing and Argument from Evidence occur throughout the design process (Common Core)

- If Create is the highest level of cognitive rigor on Bloom’s Pyramid, then everyone needs access to spaces where they can "make" in a K-12 environment.
<table>
<thead>
<tr>
<th>Math</th>
<th>Science</th>
<th>English Language Arts</th>
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<tbody>
<tr>
<td><strong>M1.</strong> Make sense of problems and persevere in solving them.</td>
<td><strong>S1.</strong> Asking questions (for science) and defining problems (for engineering).</td>
<td><strong>E1.</strong> They demonstrate independence.</td>
</tr>
<tr>
<td><strong>M2.</strong> Reason abstractly and quantitatively.</td>
<td><strong>S2.</strong> Developing and using models.</td>
<td><strong>E2.</strong> They build strong content knowledge.</td>
</tr>
<tr>
<td><strong>M3.</strong> Construct viable arguments and critique the reasoning of others.</td>
<td><strong>S3.</strong> Planning and carrying out investigations.</td>
<td><strong>E3.</strong> They respond to the varying demands of audience, task, purpose, and discipline.</td>
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<td><strong>M4.</strong> Model with mathematics.</td>
<td><strong>S4.</strong> Analyzing and interpreting data.</td>
<td><strong>E4.</strong> They comprehend as well as critique.</td>
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<td><strong>M5.</strong> Use appropriate tools strategically.</td>
<td><strong>S5.</strong> Using mathematics, information and computer technology, and computational thinking.</td>
<td><strong>E5.</strong> They value evidence.</td>
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<td><strong>M6.</strong> Attend to precision.</td>
<td><strong>S6.</strong> Constructing explanations (for science) and designing solutions (for engineering).</td>
<td><strong>E6.</strong> They use technology and digital media strategically and capably.</td>
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<td><strong>M7.</strong> Look for and make use of structure.</td>
<td><strong>S7.</strong> Engaging in argument from evidence.</td>
<td><strong>E7.</strong> They come to understanding other perspectives and cultures.</td>
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<td><strong>M8.</strong> Look for and express regularity in repeated reasoning.</td>
<td><strong>S8.</strong> Obtaining, evaluating, and communicating information.</td>
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* The Common Core English Language Arts uses the term “student capacities” rather than the term “practices” used in Common Core Mathematics and the Next Generation Science Standards.
Commonalities Among the Practices in Science, Mathematics, and English Language Arts

Based on work by Tina Chuek ebl.stanford.edu
### Performance Expectations That Incorporate Engineering Practices

<table>
<thead>
<tr>
<th>Grade</th>
<th>Physical Science</th>
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<th>Earth and Space Science</th>
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TECHNOLOGICAL LITERACY:

The knowledge, skills and abilities that every human needs to have in order to think and act responsibly with regards to technology in an increasingly complex and global society (ITEEA, 2000)
Areas of the Designed World used to organize the study of technology

- Construction
- Manufacturing
- Transportation
- Communication & Information
- Power & Energy
- Biotechnology (Medical & Agricultural)
ED-TECH TRENDS:

Flipped Classrooms / Personalize Learning

iTunes U

Promotion, Content, Branding, Sourcing

Technology
ED TECH REFORMS

Rapid Prototyping (CAD/CAM)
MAKERSPACES / FABLABS
ENGINEERING
DEFINITIONS:

“E” - Engineering as a vocation or career

“e” - Engineering-Design Pedagogy curriculum // instruction // assessment
Six Engineering Habits of Mind include...

- Systems Thinking
- Creativity
- Optimism
- Collaboration
- Communication
- Attention to Ethical Considerations
ISTEM CURRICULA.
ISTEM CO-CURRICULARS

- Future City Competition
- Odyssey of the Mind
- FRC (FIRST Robotics Competition)
- TSA (Technology Student Association)
- Conqueror of the
ISTEM CO-CURRICULARS