Elementary Engineering Teacher Professional Development: Initiation to Integration

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Outline of Presentation

- INSPIRE's Elementary Engineering Teacher Professional Development
- Teacher Stages with Engineering Education
- Strategies for Easing Progress Through Stages

NSF DRK12: R&D: Quality Cyber-Enabled, Engineering Education Professional Development to Support Teacher Change and Student Achievement (E2PD)

- 5-year project with large south-central US school district (50 elementary schools)
- ~170 grade 2-4 teachers (and their students)
- Cohorts: two-year teacher commitment
  - Elementary engineering teacher professional development in summers
  - Academic year implementation of engineering lessons
- Cohorts 1-3: Teacher teams from 13 schools
- Cohort 4: Five schools fully committed
- Cohort 5: Four schools fully committed

Teacher Professional Development (TPD) Program

INSPIRE Summer Academy

- Year 1: week-long TPD program
- Year 2: 3-day follow-up
- Goals
  - Convey a broad perspective of engineering
  - Articulate differences between engineering and science thinking
  - Develop a level of comfort in discussing engineers and engineering with elementary students
  - Use problem-solving processes to engage students in open-ended problem solving

Sources for Developing TPD

Engineering is Elementary

Museum of Science

National Center For
Technological Literacy

DESIGN SQUAD

INSPIRE!™

Academic Year (Minimum) Commitment

- What is technology?
- What is engineering?
- Introduction to the Engineering Design Process
- *Engineering is Elementary* Unit
  – Connected to grade level science standards

Teacher Stages with Engineering Education

1. Fear of Engineering
2. First Year Implementation
   – Consumed with Logistics
3. Towards Fidelity

Stage 1: Fear of Engineering

What are the sources of this fear?

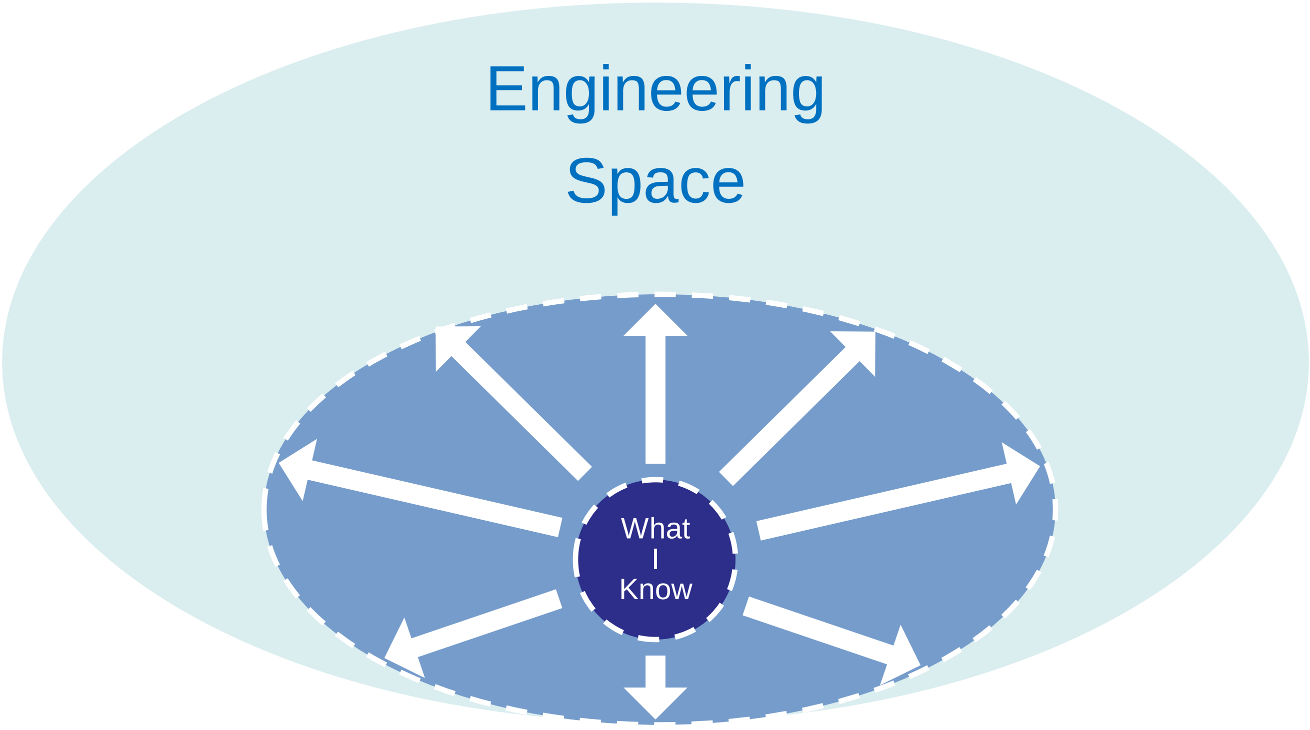
Stage 1: Fear of Engineering

Sources of Fear

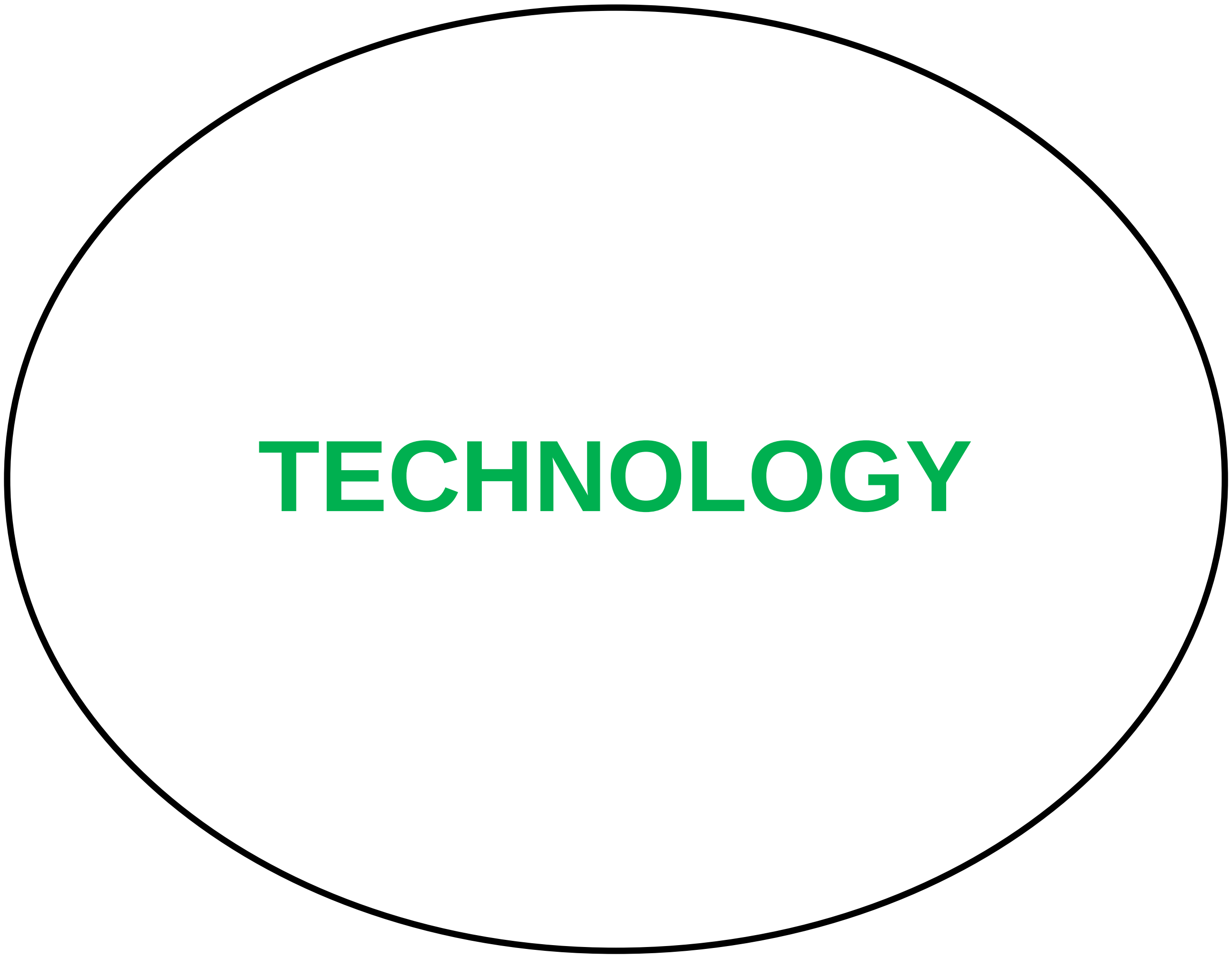
- Afraid of not knowing and looking dumb to PD providers (especially engineers)
- Afraid content will be very technical (“over my head”)
- Not for me, so may not really be for all (any?) elementary students
- Work expectations over and above

Strategies for Addressing Fear of Engineering

- What is technology?
  - Initial Source: Museum of Science, Boston



What is Technology?
Circle Map



What is Technology?
Circle Map

Washer & dryer

lamp

Scientists' use

Gives info

phone

robots

TECHNOLOGY

cars

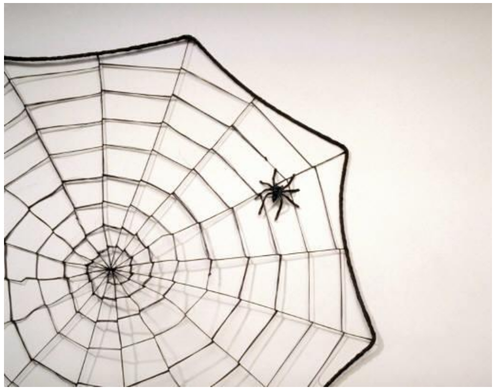
It's electric – plugged in

computers

has a battery

TV, radio, remote control









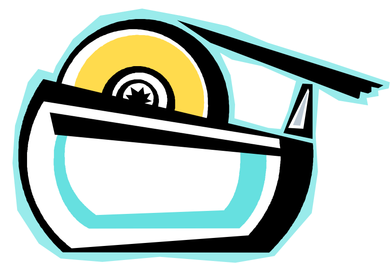
What is technology?

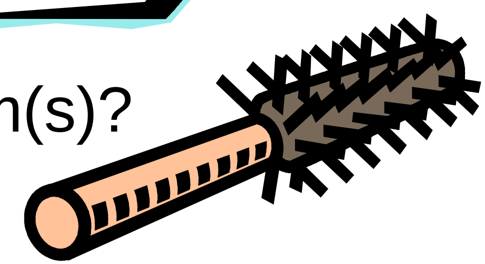
An evolving definition:

*Any **object** or **process***
*that **people create and use***
*to **solve** a problem or*
***enhance** the current quality of life*

What is technology?
Exploring Everyday Objects
(Initial Source: Museum of Science, Boston)

- Examine your everyday technology
- What is your object?
  - Sketch your object. Label the parts.
  - What problem(s) does it solve?
  - How does your object solve the problem(s)?





- Engineers and technology
  - What material(s) is your object made of? Why?
  - What needed to be considered when this object was designed?

What is technology?

Compare Two Objects With Similar Function

1. What are the objects?
2. What is their purpose?
3. What do they do? How do they do it?
4. Who is(are) the user(s) of the object?
5. What materials are the objects made out of? Why?
6. What are similarities between the two versions?
   - What are differences?
   - What changes were made? Why were changes made?
7. What needed to be considered when the objects were designed?
   - How does it work? How do the parts work together?
   - How are the parts kept together?
   - How long should the object last? How could it break? What keeps it from being broken?
8. What different types of engineers contributed to the design and creation of these objects?
9. What other versions of objects exist?
10. What could be improved about the objects?
11. What questions do you have about the objects?

What is engineering?
How is this related to engineering?

- I believe this is a good example of engineering because ____.
- *Is this technology?*
- *What problems does it solve?*
- *What are desired functions?*
- *What engineers are involved?*
- *How are they involved?*

Running Shoe

What is engineering?
How is this related to engineering?

Design

(Prototype)

- Biomedical
  - Mechanical
- Materials
  - Chemical
- …

Manufacturing

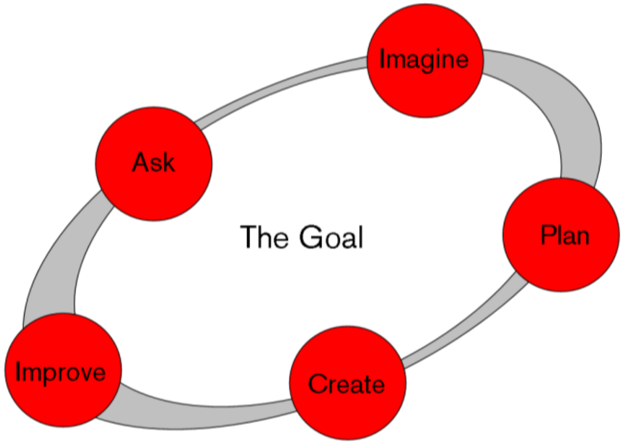
(Mass Production)

- Materials
  - Chemical
- Electrical
  - Computer
- Mechanical
- Industrial
- …

Life Cycle

Strategies for Addressing Fear of Engineering

- Motivation
  - Who becomes an engineer?
- Simple, short EDP activities
  - Index Card Tower
  - Paper Table (Design Squad)
- Access to engineers
  - Panel discussion with practicing engineers
  - Tour a manufacturing facility (engineer guide or engineering focus)
- Practice teaching an engineering lesson in non-threatening setting
  - Summer camp associated with TPD



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Museum of Science
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Stage 2: First Year Implementation

Stage 2: First Year Implementation

- Time lag from TPD to classroom implementation
  - Forget, even with good notes
- Engineering requires stuff
  - Set-up and maintenance required
  - Familiarity (e.g. pulleys)
- Classroom logistics
  - Timing with materials & content
  - Managing productive chaos
    - Student team dynamics & differing pace
    - Unknown reactions and actions of students (e.g. safety, mess)

Strategies for Addressing First Year Implementation

<u>Goal</u>: *Not make this the ONLY year of implementation*

- Refresher Before Implementation
- Team Teaching (in same classroom)
  - Sharing the teaching engineering experience
  - Opportunity for teaching 2x (or more) in one year
- (Non-threatening, By-Invitation) Engineering Education Support Specialist in Classroom
  - Eyes-and-ears, provide cues, debrief & feedback
  - Manage materials

Strategies for Addressing First Year Implementation

Goal: *Not make this the ONLY year of implementation*

- Instruction on Teaching with Student Teams
  - Class developed code of cooperation (make visible)
  - Roles of team members
  - Start with shorter team lessons (e.g. EDP) to establish norms

Stage 3: Towards Fidelity

Stage 3: Towards Fidelity
What does fidelity look like?

- Fluid conversations
  - Work of engineers & engineering in our world
- Strategic integration with & connections to other subjects
  - Science and Math: connections improve; aware of student learning
  - Social Studies: provides context (past, present, future)
  - Language Arts: communication of ideas & work, reflection, research
- Commitment to engineering education
  - Adopting & developing authentic engineering lessons
  - Implementing an authentic EDP
  - Establishing learning objectives for engineering
- Imbedded authentic assessment: processes & products

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Adopting & Developing Authentic Engineering Lessons

Engineering Design Activities – Making Strong Connections to Curriculum

- The problem is set in a context:
  - The **technology prototype** being designed solves a problem for *many* users. It is not just a one-time solution for personal use.
  - The design activity can be framed in terms of a clear **goal** with **user(s)** and possibly a **client** in a setting
  - The **design criteria** and **constraints** can be clearly stated

Framing an Authentic Engineering Design Activity

Goal: XXX
Client: YY
User: ZZZ

Criteria: XX must:

- yy
- yy

Constraints:

- XXX
- Work in pairs or teams of 3-4
- Time: Y minutes

Tools:

- Crayons/Markers
- Ruler
- Scissors
- …

Example: Pop-Up Card

Goal: Pop-up “Engineering Night” Invitation Card
Client: Westmark Pop-Up Card Company
User: Students, Parents, School District

Criteria: The card must:

- have at least two pop-up parts - one foreground and one background
  - Pop-ups must function reliably in 10 repeated tests
  - Pop-up parts must be contained within the card when it is folded
- have an invitation message
- be neat and attractive
- fit into a 9 x12 inch envelope

Constraints:

- Construction Paper
- Card Stock
- Tape
- Work in pairs
- Time: 25 minutes

Tools:

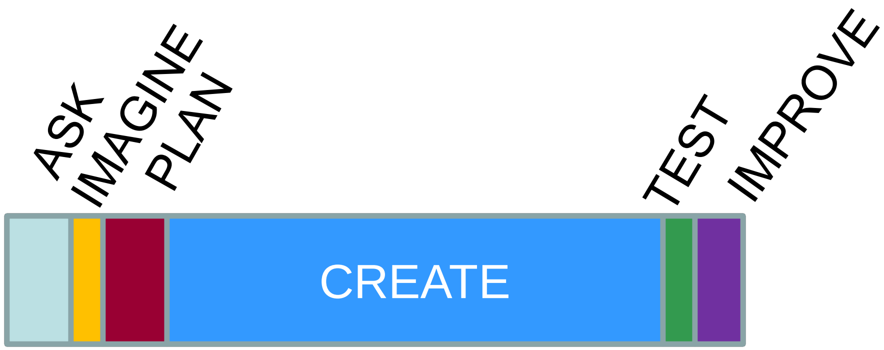
- Crayons/Markers
- Ruler
- Scissors

Engineering Design Activities – Making Strong Connections to Curriculum

- Multiple solutions (designs of the technology) are possible
- Creativity is encouraged
- Teamwork is possible
- **Mathematics, science, social studies, reading/writing concepts are inherently present and can be explored through the activity**
- The engineering design process is employed explicitly
- Improvements to the designed technology are made based on evidence

Implementing an Authentic EDP

- **Low integration into curriculum**

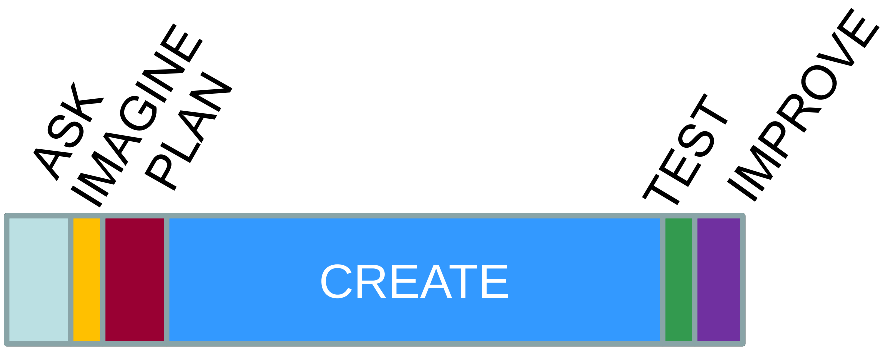


Missed Opportunities:

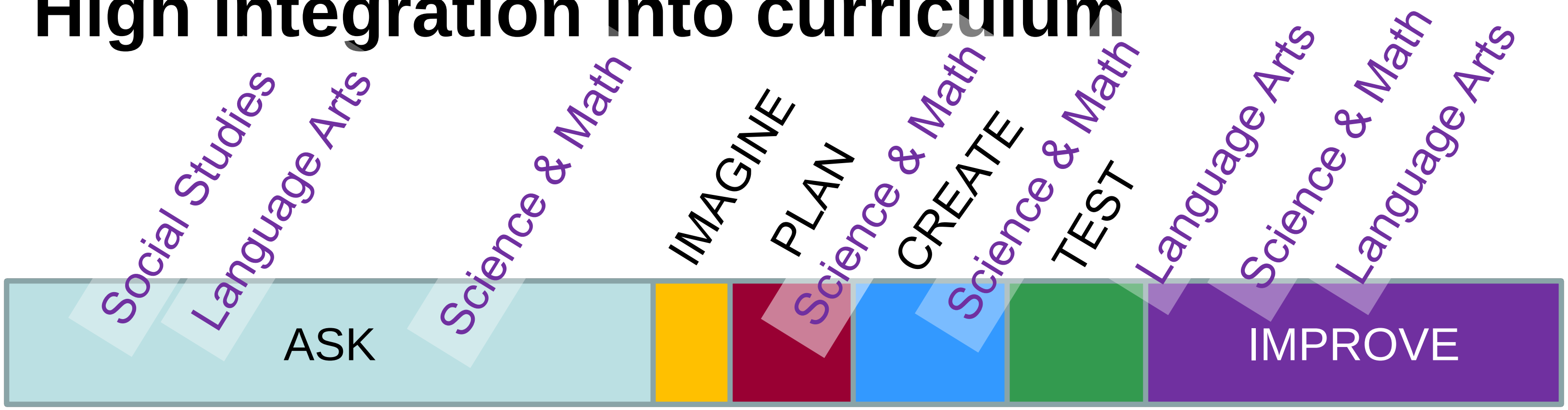
- Design is informed by many things
- Engineers do more than build/make
- Engineers use more than technical knowledge & skills
- Learn from failure

Implementing an Authentic EDP

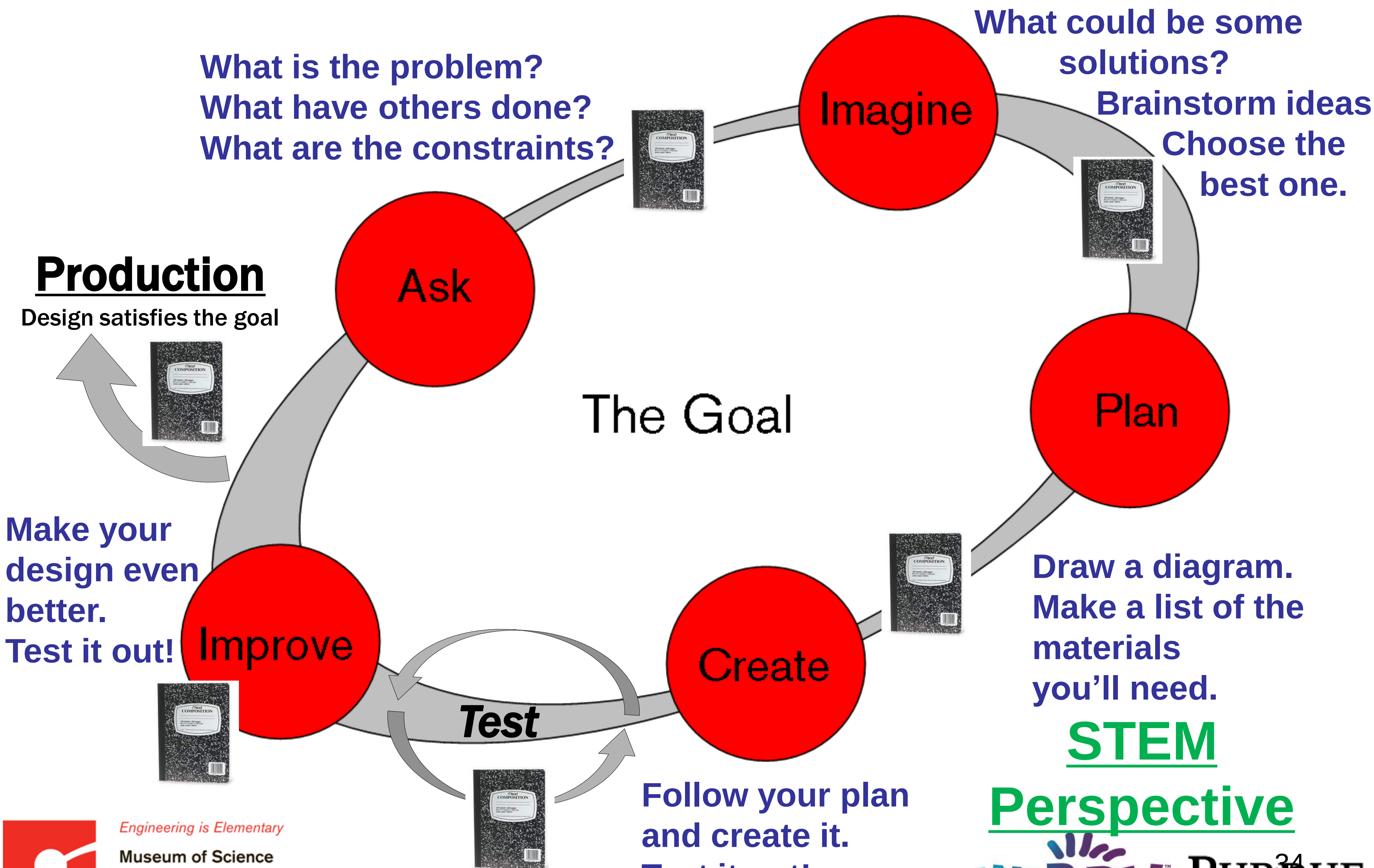
- **Low integration into curriculum**



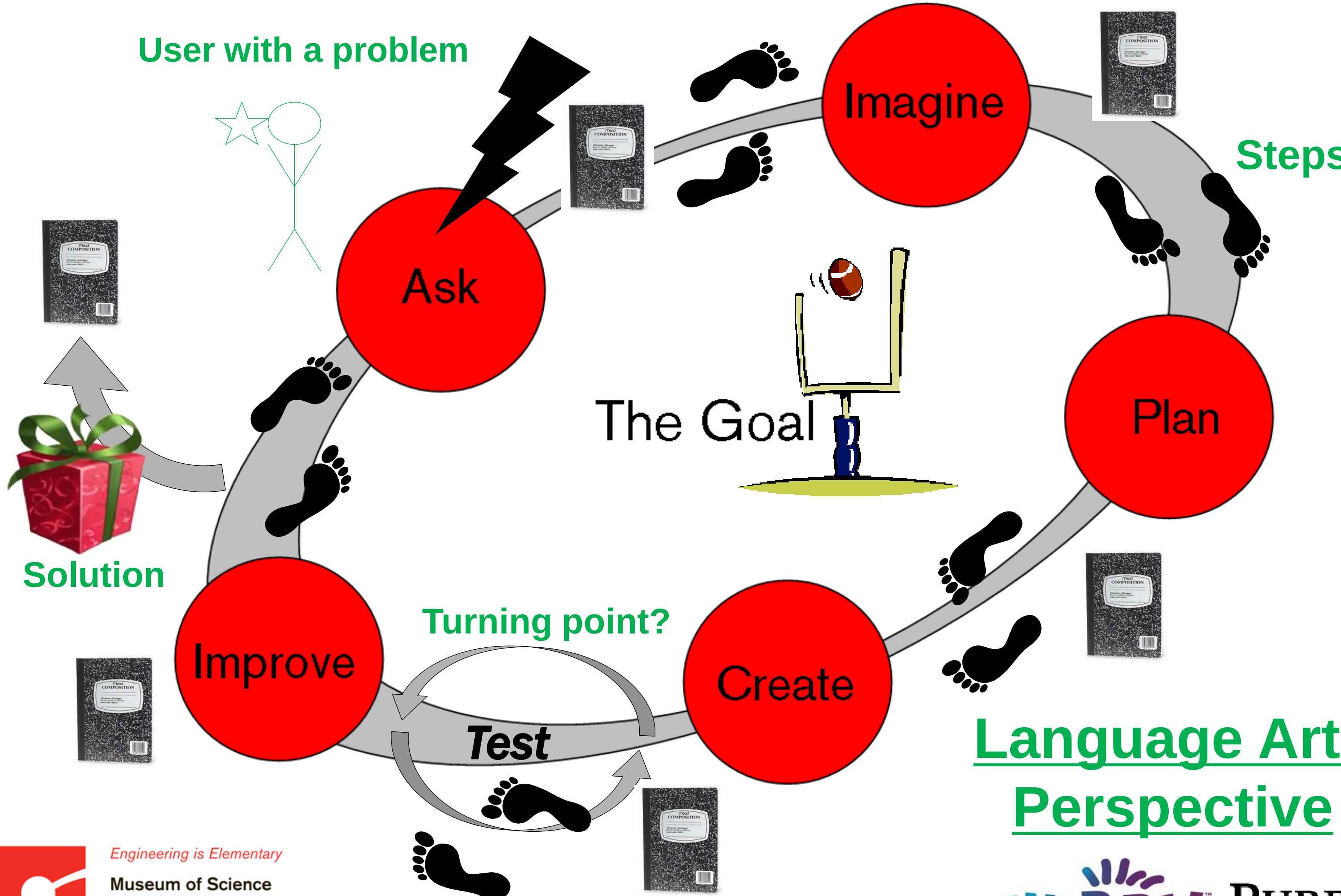
- **High integration into curriculum**



Engineering Design Process



Engineering Design Process



Language Arts Perspective

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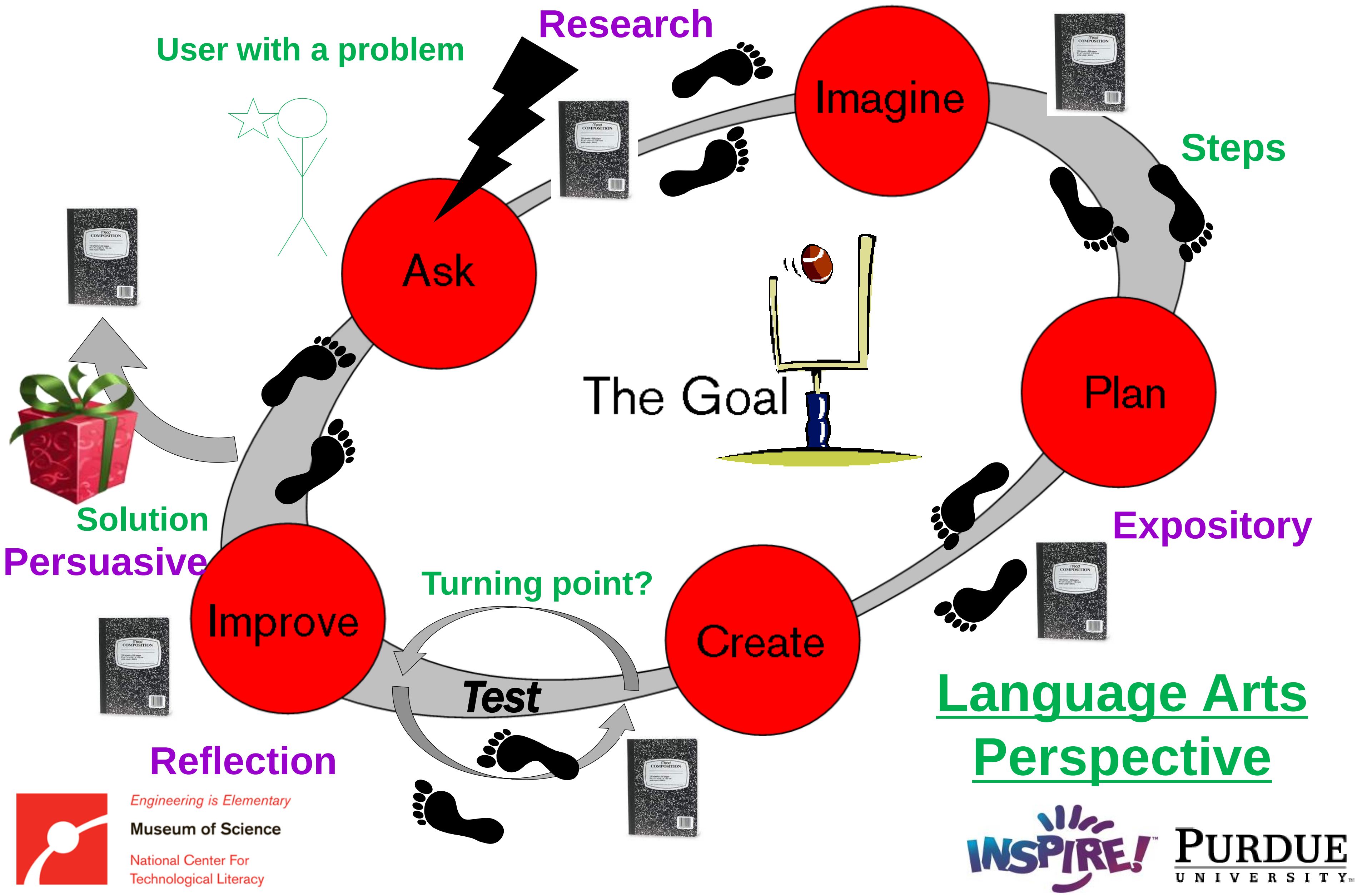
Engineering Design Process



Takeaway: Teacher Go Through Stages with Engineering Education

1. Fear of Engineering

   Goal: Increase understanding of engineering

2. First Year Implementation

   Goal: Minimize stress

3. Towards Fidelity

   Goal: Sustain engineering education through integration and authentic engineering practice

Questions?

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