Impactful Innovations: Engineering Our World

RESET AN AEOP EFFORT aeop

Authors

Dr. James Hernandez

Vishaun Ezell

Mansoureh Amiri

SUBJECT/GRADE LEVEL

Subject Area: Introduction to Engineering Design and Technology

Grade Level: Middle School

Materials

ENGAGEMENT(per team of 2-4)

Tower

- **12 straws**
- **1 yard of masking tape**
- **small plastic balls (and other items to add to the structure)**
- **Scissors**

ELABORATE

Prototype playground

- **Cardboard**
- **Scissors**
- **Paper**
- **Digital Design Software (optional)**
- **Glue**
- **Tape**
- **Pencils**
- **Erasers**

STANDARDS

Next Generation Science Standards

- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Mathematics Standards | Common Core State Standards

- MP.2 Reason abstractly and quantitatively. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4)

- 7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3)

English Language Arts Standards | Common Core State

- RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ETS1-3)
- WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2)
- WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2)
- SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ETS1-4)

LESSON OBJECTIVE(S)

Students will engage in the full engineering design process—from identifying problems and researching existing solutions to brainstorming, prototyping, testing, and refining their own designs—while considering criteria, constraints, and environmental impacts. They will work collaboratively to analyze data, communicate their findings, and reflect on the broader implications of engineering solutions. Throughout, students will integrate research, creativity, and critical thinking to develop effective, sustainable, and well-justified design outcomes.

CAREER CONNECTION(S)

Mentor Background: Dr. Benjamin D. Nye is the Director of Learning Sciences at the University of Southern California, Institute for Creative Technologies. Ben's major research interest is to identify best practices in advanced learning technology, particularly for frontiers such as distributed learning technologies (e.g., cloud-based, device-agnostic) and socially situated learning (e.g., face-to-face mobile use). His research interests include modular intelligent tutoring system (ITS) designs, modeling social learning and memes, cognitive agents, and educational tools for the developing world and low-resource/low-income contexts. Teacher mentees studied and researched, worked on mobile adaptive learning ecosystems, such as Personal Assistant for Life-Long Learning(PAL3), open-source and user-authorable tutoring chat dialogs (OpenTutor), ABE, and Agile Software.

STEM Careers: Engineering, Civil Engineering, Structural Engineering, Technology

ENGAGEMENT (1-3 days)

Brief Description: Students will be introduced to the engineering design process and its impact on people and the natural environment through video, note-taking, worksheets, whole-class discussions, small-group discussions, polling, and real-world connections.

SlideShow : ENGAGEMENT (1-3 days)

Materials Needed to build the bridge/tower (per team of 2-4 students): **12 straws, 1 yard of masking tape, small plastic balls (and other items to add to the structure), scissors**

Procedures: Students will build the tallest and/or largest bridge or tower that can hold more than one object (plastic ball, pennies, marbles) as much as possible.

- Expectations for Bridges/Towers
    - Each bridge or tower should stand by itself - tape can't be used to secure the bridge or tower to the table.
    - The bridge/tower should be constructed to place the plastic ball at the top of the structure without using your hands/body parts or tape (ie, nothing can be used to hold the plastic ball on top of the structure).
    - Bridges/Towers should be completed within 10 minutes.
    - Plan improvements
    - Add Constraints/Limitations
    - Redo Activity with improvement

Exit Ticket:

- Use an interactive tool (like Kahoot orKahoot to conduct a quick live poll on the following questions (feel free to use as little or as many as you like):
    - What design problems are most pressing in your community?
    - Why do you think it is important for designers and engineers to use sustainable

materials in their projects? What are the potential benefits?
- In what ways should community members be involved in local engineering and design projects? Why is their input valuable?
- When creating a playground or recreational area, how would you balance safety and fun? Can you provide examples of how this balance might be achieved?
- How should engineers consider the environmental impact of their designs? What specific factors should they focus on?
- What aspects of engineering or design interest you the most? How do you see yourself contributing to these fields in the future?

Differentiation Considerations:

a. For students with IEPs - provide printed instructions.
b. For ELL students - give them more time to complete.
c. For lower level thinkers - pair them with higher level thinkers as best as you can or ask groups who have completed the task to assist.
d. For higher level thinkers - using chromebooks, open the AI Link, research how to create the tallest and the strongest tower, with similar material and build what AI has suggested.

EXPLORATION (2-4 days)

Brief Description: Students will research and document an engineering design, identifying the problem it solves.

SlideShow: Copy of EXPLORATION (2-4 days)

Procedures: Show the YouTube video that describes the engineering design process. Print or create an online way for students to complete the following worksheet while observing the video. Students may also take notes during the video.

Optional: Bell Ringer

***Standup meeting questions*:** These questions are designed for groups to share their progress on their projects. This can be done every class period or when there is a checkpoint in the projects. This practice is meant to guide the groups while also having students hold their teammates accountable.

Note to Teachers: Use Padlet to display individual responses to the class discussion questions and/or chart paper and markers for team responses.

- Question 1: Engineering Challenges
  Teacher: "First, let's talk about challenges. What engineering challenges did you notice in the video we saw? Were there any specific difficulties the engineers faced?"

- Question 2: Impact on Lives
  Teacher: "Now, let's consider the impact of these projects. How do you think engineering solutions affect people's lives? Are there benefits or drawbacks?"

- Question 3: Environmental Concerns
  Teacher: "Let's delve into environmental concerns. What environmental issues do you think engineers must consider when designing these projects?"

Small Group Research:

- In small groups (2-4), students will research different engineering designs that solve a problem.
- Allow students to research engineering designs.
- Students will document their work in a presentation software like Canva/ Google Slides.

Examples could include:

- Bridges
- Skyscrapers
- Renewable energy
- Transportation
- Water Management
- Robotics

Document the following for the researched design:

- Materials used
- Safety Features
- Aesthetics
- Energy Efficiency
- Cost
- Safety Considerations
- Maintenance
- Obstacles/Challenges
- Market Research-Siri Video

English Language Learners:

- Provide translated versions of research templates.
- Use Graphic Organizer

Students with IEPs:

- Provide simpler form of templates
- Pair with a peer or allow individual research if group work is a challenge.
- Give additional time

Advanced Learners: Encourage additional questions like: How could this design be improved using newer technology?

EXPLANATION (2-3 days)

Brief Description: Students will understand the importance and process of defining a problem and review the engineering process.

Slideshow: EXPLANATION(2-3 days).

Procedures:

Teachers will go through each stage accompanied by the videos.

After the videos, the teacher will explain the different steps in the engineering process.

The Engineering Process, according to the video, includes:

- Define the Problem
- Do Your Research
- Develop a Possible Solution
- Design Your Solution
- Build a Prototype
- Test it

Defining Success Video

Student Questions and when to contact the instructor:

- **Institute (3) Before Me**
  - **Students will ask three other people before asking you for help after you have provided detailed lessons (verbally/hand-out/Google Slides.**
  - **After completing: Three-Before-Me students may ask their individual/group questions.**

English Language Learners:

- **Provide key vocabulary visuals. For example: prototype, constraint, evaluate,..**
- **Use closed captioning on videos.**
- **Offer sentence starters and allow verbal or recorded responses.**

Students with IEPs:

- **Offer guided notes with fill-in-the-blanks.**
- **Use graphic organizers for problem definition.**
- **Allow extra time and check for understanding during each step.**

Advanced Learners:

- **Ask them to find a current engineering challenge in the news and write a formal problem statement.**
- **Have them propose initial criteria and constraints independently.**

Optional: Exit Ticket lesson (not in the Slideshow):
ENGINEERING DESIGN PROCESS MATCHING CHALLENGE

Answer Key: 1C, 2F, 3D, 4B, 5G, 6A, 7E

ELABORATE

Brief Description: Students will reflect on previous learning to brainstorm and create a prototype of an engineering design of a playground.

Slideshow: ELABORATE Student Rubric and Checklist

Materials Needed: **Cardboard, Scissors, Paper, Digital Design Software (optional), Glue, Tape, Pencils, Erasers**

Procedures:

Group Brainstorming/Planning

- Groups will brainstorm ideas and sketch their initial playground designs on paper, journal or digital devices.
    - **Optional**: Utilize Canva or other AI image generation tools to create designs.
    - Add Criteria and Constraints to build
- Brainstorm your own engineering design.
- Encourage students to think creatively about how to blend fun with safety and sustainability.
- Each Group will share what they found and came up with during the whole group discussion and receive feedback. Use the Writing Feedback Tool on MagicSchool to receive feedback on your research ideas.

Possible reflection questions:

- What scientific principles guided your group's choices?
- How did you ensure your design was safe and environmentally friendly?
- What potential challenges might arise in the implementation of your playground?

Prototype Creation

- **Teacher Script:** Today you will create a prototype of the design you brainstormed with your team. Each group will create a simple prototype using the materials provided. Make sure to communicate with your team.

Optional: Bell Ringer Writing Activity: Five (5) Minute Write Session

Students are asked to write about a magical experience on the playground. If he/she did not have a magical experience then he/she should still be able to write about an experience. This optional assignment is provided in order to follow ELA standards.

English Language Learners:

- Provide visuals of playground parts like: slide, swing, ramp
- Use sentence structure.For example:Our design is safe because…

Students with IEPs:

- Allow verbal planning instead of written.
- Use simplified templates for sketching.
- Assign clear roles in groups like: reporter,designer,...

Advanced Learners: Ask advanced groups to **create a short survey** and collect feedback from classmates, younger students, or family.

EVALUATION

Brief Description: Students will present their projects to the class.

Slideshow: EVALUATION

Procedures: Teacher Script: Today you will present your reflections to the class.

Peer Review

AI Application: Students can create a video/transcript for presentation and upload it to LLM for questions. Examples of LLMs: Abe Writing, MagicSchoolAI, ChatGPT

Group Presentations

Teacher Script: Today you will present your prototypes of the playgrounds that you have been working on over the past few days.

- Groups present their proposed playground designs to the class, highlighting:
  - The criteria they considered.
  - The constraints they faced.
  - How they incorporated scientific principles in their design.

Group Feedback

- Students and the teacher will give feedback to the presenters.
  Possible questions are:
  - What challenges did you encounter?
  - What worked well in your group's design?
  - How did you address potential negative impacts on the environment?
  - How would you improve your design?

Teacher Script: Today you will reflect on the feedback from your peers and teacher and create a presentation.

- Choose at least one aspect of the design that you would improve and why.
- Suggest changes based on feedback received from your peers and teacher.
- Discuss how your design could impact the community positively or negatively

Differentiation Considerations:

English Language Learners :

- Allow presentation in English with visual support.
- Offer sentence starters:One thing we changed was…

Students with IEPs:

- Allow shorter presentations or allow presenting in a smaller group setting.
- Allow alternative formats like recorded video,
- Use graphic organizers for reflection prompts.

Advanced Learners:

- Ask questions like how would you get the city to support your design?
- Redesign a part of the prototype based on peer feedback and explain how it improves the solution.

REFERENCES

- https://www.youtube.com/watch?v=t6r73lFaIzY&t=341s- Intro to the Engineering Design Process for Elementary & Middle School, NGSS 3-5-ETS1-1, MS-ETS1-1
- https://docs.google.com/document/d/1r3SHIkaSICR9tpf3TS2grSvhnBxE9h5u/edit -IntrotoTheEngineeringDesignProcessVideosheetEaselmoreV4-3
- Defining the Problem: https://www.youtube.com/watch?v=OyTEfLaRn98
- The Engineering Process: https://www.youtube.com/watch?v=fxJWin195kU&t=1s
- Defining Success: https://www.youtube.com/watch?v=XyFUqFQfl30&list=PLhz12vamHOnZ4ZDC0dS6C9HRN5Qrm0jHO&index=4