Making Maglev Cars with the Engineering Design Process

STEM: Science, Technology, Engineering, Mathematics

SCHOOL IMPROVEMENT NETWORK

STEM Classroom Series

The STEM Classroom Series features lessons that promote understanding of STEM content knowledge, integrate STEM with non-STEM subjects, and increase students' exposure to STEM-related career options.

About this Segment

At Westridge Elementary in Provo, Utah, 5th grade students have completed a unit about magnetism and now engage in an engineering project to design and create maglev cars. Over the course of three days, the students will work collaboratively through the steps of the engineering design process to construct, test, and improve their maglev cars.

Application activities **(complete all that meet your goals for viewing this segment)**

A. Learn more about STEM education

1. In the table on the next page, identify the elements of effective instruction, as well as the elements of effective STEM instruction, that you observed in this lesson.

2. How could the teachers enhance or add to the elements of instruction in their lesson?

3. How could the teachers enhance or add to the elements of STEM instruction?

C. Infuse STEM principles into your own lessons

1. Apply the six questions in the "Replicate this lesson" activity to one of your own lessons.

2. Determine challenges you might face in applying these STEM concepts to your own lesson. How can you overcome these challenges?

B. Replicate this lesson

1. *What are the learning objectives you want your students to achieve?*
   How would you modify the lesson's objectives, outlined in the Lesson Plan below, for your own students and curriculum? What other objectives, if any, will you set?

2. *What content knowledge do you need to acquire or expand?*
   This activity relies on an understanding of magnetism and the engineering design process. Which of these concepts do you need to learn more about? Visit the Content Knowledge links in the Resources section below.

3. *How will you create the time and space to engage students in this lesson?*
   How much time will this learning activity take to plan and carry out? How can you integrate the activity into your current curriculum map?

4. *What materials and other resources do you need for this lesson?*
   What resources are needed for this lesson, including collaboration with other teachers and with administrators? See the Resources section of the lesson plan.

5. *How will you assess student learning?*
   In this unit, students created their own list of assessment criteria for their cars (see Appendix) and informally assessed their cars at the end of the project (note that not all criteria listed proved assessable).

6. *How can you promote a STEM focus in your instruction?*
   What STEM experiences were students engaged in during this lesson (see the "Elements of Effective STEM Instruction" below)? What are some others that you could include?

Elements of Effective Instruction	Elements of Effective STEM Instruction
- High expectations for all students - Rigorous content - Authentic performance tasks - Real-time assessment adapted to student needs - Student-driven learning - Strong relationships among students and between teacher and students - Equitable, culturally relevant content and practices - Evidence of 21st century skills, e.g. critical thinking, problem solving, collaboration, creativity, communication - Technology that enhances learning - Cross-curricular (interdisciplinary) integration	*In addition to the Effective Instruction elements at left, Effective STEM instruction can include:* - Hands-on problem-solving activities that have real-world relevance - Integration of STEM into non-STEM subjects, especially art and design - Use of industry-standard software, tools, and procedures such as the engineering design cycle - Increased awareness of STEM fields and occupations, especially among underrepresented populations - Enthusiasm about further STEM-related learning - Connections between in-school and out-of-school learning opportunities - Industry and higher-ed partnerships that encourage hands-on student exploration of STEM-related careers - Teachers who are demonstrating and proactively building deep STEM-related content knowledge

Resources

Content Knowledge

Bonsor, K. (n.d.). How maglev trains work. How Stuff Works. Retrieved January 22, 2015, from http://science.howstuffworks.com/transport/engines-equipment/maglev-train.htm

Engineering Is Elementary (2015). The engineering design process. Retrieved January 22, 2015, from http://www.eie.org/overview/engineering-design-process

NASA. (2013). Engineering design process. http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html - .VMF7lGTF8a0

Teaching Materials

Engineering Is Elementary (2015). The attraction is obvious: Designing maglev systems. Unit plan and resources. Retrieved January 21, 2015, from http://eie.org/eie-curriculum/curriculum-units/attraction-obvious-designing-maglev-systems

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Califronia Department of Education (n.d.). Science, technology, engineering, and mathematics. Retrieved January 22, 2015, from http://www.cde.ca.gov/pd/ca/sc/stemintrod.asp

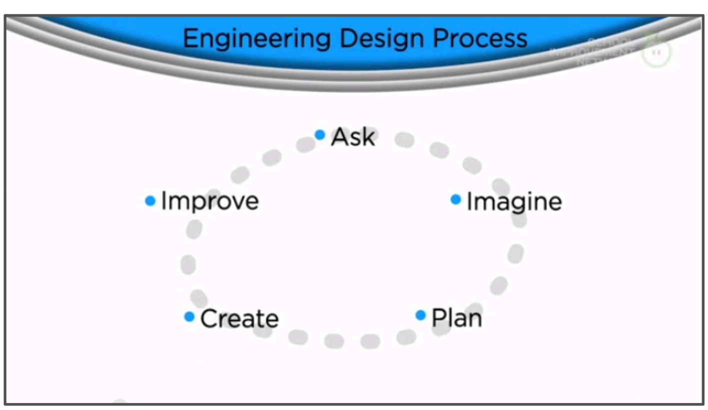
PBS Learning Media (n.d.). Inspiring middle school literacy: Science and health topics. Retrieved June 12, 2014, from http://www.pbslearningmedia.org/collection/midlit/?topic_id=321

STEM Education Coalition (n.d.). Home page. Retrieved January 22, 2015, from http://www.stemedcoalition.org/

STEM to STEAM (n.d.). Home page. Retrieved January 22, 2015, from http://stemtosteam.org/

US Department of Education (n.d.). Science, technology, engineering, and math: Education for global leadership. Retrieved January 22, 2015, from http://www.ed.gov/stem

Utah STEM Action Center (n.d.). STEM Utah. Retrieved January 22, 2015, from http://stem.utah.gov/



Making Maglev Cars with the Engineering Design Process

Teacher Lesson Plan

Teachers: Mashell Brown, Allison Fuller, and Megan Jenkins	**School Name:** Westridge Elementary		**Location:** Provo, Utah
Grade Level: 5th	**Content Area:** Science	**Lesson Duration:** 3 days, 1 hr per day	**Lesson Date:** 11/19, 20, & 24, 2015

Overview	Students have completed studying a unit about magnetism and will now create maglev cars.
Objectives	Demonstrate an understanding of magnetic polarity and the engineering design process in designing, creating, testing, and improving a maglev car. Work collaboratively in pairs and follow the engineering design process in creating the car.
Prior Knowledge and Skills Needed (Teachers and Students)	Flat magnetized objects have positive and negative polarity, which will attract or repel other magnets depending on how they face each other. Students must be sure to fasten magnets on their cars so that the magnets repel the magnets lining the track. The steps of the engineering design process (Ask – Imagine – Plan – Create – Test – Improve). See image on preceding page.
Cross-Curricular Integration	Students demonstrate literacy skills by writing captions and explanations for their design diagrams.
Differentiation	Students receiving special services will have assistance to ensure that the magnets attached to their car face the track magnets with the same polarity facing each other, thus causing repulsion.
Resources	**Unit materials***:* See Teaching Materials link in the Resources section on the previous page **Lesson resources:** Two sheets of poster paper, diagram task sheet (see Appendix for these three items) **Car materials:** For car construction: scissors, rulers, hot glue gun (to attach magnets to car body), and in the materials bag: a piece of sandpaper and a glue stick -Sufficient disc or rectangular magnets for four magnets per car (with several spares) -One materials bag (Ziploc type) per pair of students. In addition to the piece of sandpaper and glue stick, each bag contains one rectangular piece each of five different materials, their size determined by the width of the track. The material types are Styrofoam (around 2-4" thick), unused meat tray, stiff cardboard, blue insulation foam, and display-board-style foam core. **Track***:* Westridge Elementary's tracks were built by engineering students at Brigham Young University, a local university partner in Westridge's STEM education initiative. Commercially constructed maglev tracks for schools can be found online. **Materials for the trials:** 150 pennies (or other small items to use for weights), two small Styrofoam cups to hold the pennies on the vehicles, and masking tape to tape the cups together and attach them to each car before its trial run.
Activity Outline	Activity takes one hour per day for three days Day 1: Students receive the task, which is to design a vehicle that will levitate above the maglev track, move down the track when given a small push, and safely transport weight. 1. Present students with the task and ask students to suggest assessment rubric indicators ("How will we know if we've created a successful car?" 2. Begin the engineering design process: Students write down their initial questions (Ask phase) 3. Hand out a sample bag of materials *without the magnets* (or students will be drawn to play with magnets) – one bag per table. 4. Imagine phase: Student pairs draw two ideas for car design and present those ideas for teacher to initial. 5. Plan: Once their ideas have been initialed by teacher, the student pair receives a diagram sheet that will guide them in further designing their car (see Appendix for diagram sheet). Day 2: Students create, test, and improve their cars according to the engineering design process. If you are doing this lesson with multiple classes in your grade, you can do performance trials at the end of the lesson, with the five best-performing cars in each class (according to success on the student rubric) running in the whole-grade activity on Day 3. Day 3: Students assemble in gym to watch the trials of each class's five top-performing vehicles. These final trials end with a "winning" car, and most importantly, whole-class sharing of takeaways from the project.
Assessment	Students informally assess their own cars according to criteria they list (see Appendix for their list—but note that not all items listed turned out to be assessable).

Appendix

Materials Poster Example

Available Materials
Disc magnets
Rectangular magnets
Glue gun and glue
Styrofoam
Foam core
Cardboard
Insulation foam
Meat-tray styrofoam
Scissors
Rulers
Sandpaper

Diagram Poster Example

Does Your Diagram Include:
- ☐ Measurements
- ☐ Materials
- ☐ Magnet placement
- ☐ Glue placement

Car Assessment Criteria
How high it levitates
How much weight it can carry
How fast it moves
How far it goes

Maglev Engineering Diagram Sheet

Names______________________________________ Design #_____

Diagram:

Description of Improvements:

*____

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