Water Transport System
Lesson Plan

Overview

Skills and connections: simple machines including pulleys, wheels, and axels, volume and density, watering needs of plants, units of measurements (length), engineering design process

Age: 4th & 5th grade

Community problem: Students in an urban school were concerned that certain garden beds in their schoolyard have no easy access to water.

Student design goals: Students created a water transportation system to move water across the school playground to the garden beds. This project required that the resulting system saved time and effort, while ensuring successful plant growth and student safety, all within a fixed budget and deadline.

Details

The students worked in small groups. Two of the groups designed and built a working prototype of a water transport system that included a double pulley mechanism. The third group designed and built a miniature mechanical model of a conveyer belt used to transport buckets of water.

Depending on which route was taken, materials used by the students included plastic pulleys, nylon rope and buckets for the former design, and rubber sheets, strings, straw-coffee stirrers, paper tubes, tapes and plastic sheets for the latter.

More Information

Module Specific Standards

- *English/Language Arts (Speaking and Listening—grade 4):* CCSS.ELA-LITERACY.SL.4.1, CCSS.ELA-LITERACY.SL.4.4
- *Mathematics (Measurement and Data):* CCSS.MATH.CONTENT.4.MD.A.1 (grade 4), CCSS.MATH.CONTENT.5.MD.A.1 (grade 5), CCSS.MATH.CONTENT.5.MD.C.3 (grade 5)
- *NGSS Standards:* 3-5 ETS: Engineering Design

Lesson Outlines

Lesson 1: Introduction to Engineering

Activity 1: A teacher-initiated whole class discussion around the question, "What does it mean to do engineering?"

Teacher Objective: To address students' ideas that engineering refers only to products that require electricity, computers, or new technology and the engineers are people who "fix" and "build" things.

Student Objective: Establish a working definition of engineering design: a process of creating solutions to human problems through creativity and the use of our math and science knowledge.

Activity 2: A warm-up design challenge completed in small groups.

Student Objective: Understand engineering and steps of engineering design as identifying a problem, thinking about ideas to solve the problem, drawing plans, proposing designs, exchanging ideas, improving the design, and building and testing a prototype.

Details: Read the book, *Muncha Muncha Muncha!* (Fleming and Karas 2002). It tells the story of a Gardener who plants a vegetable garden but every morning when he goes to pick the vegetables, he finds destroyed plants. He notices animal tracks and concludes it's the bunnies and squirrels eating his vegetables. After the story is read to the students, ask the students, "Did the gardener have a problem? What was his problem? Could we use engineering to solve his problem?"

The students then in small groups brainstormed ideas to solve the problem. Each group then presented their design to the whole class. After each design presentation, each student in the class gave a written feedback about the design to the presenters. The students then, back in their small groups, revised their designs as per feedback and then built models of their garden protection system with connectable building blocks. This purposeful material restriction should be accounted as a design constraint, a part of the engineering design process. The built structures were tested for stability and purpose (try answering the question, does the built structure serves its purpose?).

The activity closed with a discussion around the various steps the students followed to solve the problem and identification of those as steps of the engineering design process. And how did engineering help solve the gardeners problem?

Lesson 2: Identify and Understand an Engineering Problem

Activity 1: A whole class discussion about the various problems the students observed in their school garden and those they thought might be solved by engineering design.

Student objective: Students should be guided to unpack an engineering problem. They should define a central engineering problem and define criteria for their solutions.

Details: As the whole class discussion began, each of the student suggestions was displayed at the front of the class. The students then sorted the problems into various groups, such as problems related to protecting plants or providing light. The discussion then focused on the importance of choosing one problem that needed immediate attention and their collective efforts. It was here that the watering problem was chosen as the focus problem.

Examples of Student Suggestions:

1. "The beds need more flowers"
2. "No water for upper garden beds"
3. "Wood chips get into the garden beds"

The opening discussion was followed by discussion around the following questions to help probe nature of the specific problem.

Design Questions:

1. Why do you think this garden problem is important?
2. How will you know if we successfully solve the problem?
3. What kids of test will the solution have to pass?
4. Are there any limitations on what we can design?
5. What information or materials might we need to solve this problem?
6. Is there anything we need to learn before we solve this problem?

This discussion helped establish the central problem and set the design criteria and constraints.

Activity 2: Brainstorm possible solutions to the problem, a small group task.

Student Objective: With the unpacking of the focus problem (criteria and constraints) in mind, make suggestions for potential solutions to the problem.

Details: The students worked in small groups where they brainstormed to suggest possible solutions to the problem and made plans. They made drawings and wrote descriptions. Each group then shared their ideas with the class, solicited feedback, and documented their initial ideas.

Lesson 3: Planning a Solution

Activity 1: Gather documenting data needed to solve the problem

Student Objective: Collect information and data that would be needed to design a watering system with the potential to be actually installed in the schoolyard.

Details: There was a need to design a system that could be potentially installed in their school yard, ushered in the requirement to measure and map outdoor space. The students in groups used small white boards and dry-erase markers to collect and write data. They took measurements of the outdoor space and mapped areas to help them design the watering system.

The mapping activity was used to make students aware of the safety of the other students on the playground and this was added to the list of criteria.

Activity 2: Make design diagrams and prepare a materials list.

The students in their small groups created design diagrams for their watering systems and made a list of materials they would need to build their prototypes. It was essential for the students to document their work.

The facilitators can even explore alternate means of documentation like audio/ video recording or tablet presentation to make accommodations and support students with different learning levels.

The groups then shared their designs for the water system with the whole class.

Lesson 4: Exploration of Concepts

During the previous activity, when the students shared their initial design, the facilitators identified the key underlying science concepts for each design. We used this information to guide the facilitation of our next activity.

Activity 1: Support development of science concepts central to the design.

Student Objective: Understand and apply the science concepts (as previously determined by the teacher based on the student designs) in the given context of designing.

Details: In this case the teachers talked about pulleys and their role as simple machines to provide support to one of the groups who had pulleys in their design. Whole class discussions and some structured instruction around simple machines and how machines reduce effort required was designed.

Activity 2: Watch a video that shows students engineering solution to another community problem.

Student Objective: Recognize the steps of engineering design

Teacher Objective: Assess student ideas about engineering design.

Details: The class watched a brief Design Squad video clip showing students engineering solutions to another community problem. The students then discussed the various engineering design practices that we had introduced earlier and pointed out those in the context of this video. They were also asked to compare and contrast their own design process to the Design Squad participant's process.

The facilitators used this student analysis of the video to assess their understanding of the design process.

Lesson 5: Building and Testing a Prototype

Activity 1: Here the students were engaged in building their prototypes with the materials provided.

Note that the facilitators brought in all the listed materials. Certain materials on the list that were not included due to cost or safety factors were replaced by suitable alternatives. The students were made aware of the substitute replacements.

Activity 2: Once the prototypes were ready, the students tested those. The groups who constructed a pulley and pump system to lift bucket of water tested their system to see if a) it could transport required amount of water, b) was stable and sturdy, c) reduced effort needed to carry heavy loads of water up the stairs and d) did not pose any potential threat to other children on the playground.

Lesson 6: Redesign and Communicate

Activity 1: Discussions and Feedback

Each of our groups shared their prototype and test results. The whole class then evaluated each design against the test criteria and discussed the pros and cons of the design. They gave each other feedback.

Activity 2: The students refined their prototypes based on feedback and test results. The revisions to design were documented.