Engineering Projects Overview

The reverse-engineering instructional model was developed and refined over two years and 15 engineering projects with two groups of fifth-grade students.

Engineering Project	**Description**
Go-Karts (Years 1 and 2)	Students designed go-karts to meet six different design challenges. Two versions of this lesson were taught each year: the original school district kit and the adapted reverse-engineering lesson highlighted here.
Rain Makers (Year 2)	Students engineered "rain makers" to measure how varying the intensity of rainwater would impact erosion and deposition on a model stream bead.
Rain Garden Models (Year 2)	In concert with the rain maker project, students designed and tested water filters to understand how rain gardens reduce and filter runoff to local watersheds.
Living Machine Filters (Years 1 and 2)	During an overnight environmental education field trip, students used everyday materials to engineer water filters that would act as "green machines" to filter wastewater.
Towers (Years 1 and 2)	Students engaged in a short design challenge to build a tower that can hold a tennis ball in the wind. Local architects assisted with students' designs during a classroom visit.
Bridges (Years 1 and 2)	Students visited a local integrated architecture and engineering firm and engaged in a bridge design challenge with architects and engineers.
Gingerbread Houses (Years 1 and 2)	After viewing a gingerbread house competition organized by local architects, students designed and built gingerbread houses for a similar in-class exhibit.
Community Engineering Night (Year 2)	Families of fifth-grade students completed the marshmallow challenge and viewed their children's engineering projects from class. Together, we discussed ways to support students' engineering interests outside the classroom.
Design Charrettes (Year 2)	To understand professional design practices, students participated in a design charrette, in which they redesigned their indoor recess space.
Cube Satellites (Year 2)	Students used sketching, Excel-based models, and physical models to design and build model cube satellites. They wrote mock NASA research proposals to fund specific cubesat missions in partnership with local aeronautical engineers.

Reverse-Engineering Go-Karts

Project Goals: Adapt a standard Models and Designs go-kart to meet various challenges.		
Materials: Wooden wheels, cardboard wheels, 4- and 7-inch wooden dowels, rubber bands, and small binder clips. Students should wear safety goggles with designing and testing their go-karts.		
Day	Activity	Step
Preles son	The day before each engineering project, the teacher described the upcoming go-kart challenge, such as "Stay Between the Lines." For homework, she asked students to write down or find pictures of ways that everyday objects already solved the design problem. (5–10 minutes)	Introduce Project and Research Everyday Solutions
1	The teacher posted the Reverse-Engineering Chart (Figure 2) at the front of the class. In small groups, students shared their observations from the night before and summarized their findings on a 5×7 note card that was posted under the "personal experience" column of the chart. (10 minutes)	Research Everyday Solutions
	As a whole class, the teacher and students read and discussed the examples that were posted to the chart and talked about how these solutions might be adapted for a go-kart. (10 minutes)	Research Everyday Solutions
	In small groups, students designed, tested, and redesigned go-karts that leveraged everyday ideas to meet the design challenge. (20 minutes)	Test Everyday Solutions
	Each student group quickly took turns testing their everyday model in front of the class, and received feedback from classmates about what they liked and what could be improved on the go-kart. (10 minutes)	Share and Describe Design Solutions
2	The teacher handed out a 5×7 note card and asked each student group to describe what worked from their everyday go-kart solution. Students discussed their answers and wrote them on the card. The teacher gathered students together for a whole-group discussion. She had each group share what it wrote on the cards, and then posted the cards to the "what worked" column on the chart. The teacher asked the whole class to discuss, "What did we learn from our everyday solutions?" and wrote student responses in the "what did we learn" column on the chart. (15 minutes)	Research Everyday Solutions
	After seeing the diversity of everyday solutions from classmates, students redesigned and tested their go-kart one more time in small groups. (15 minutes)	Test Everyday Solutions
	The teacher asked students to describe the "science ideas" that seemed to apply to all of their go-karts. Students engaged in argumentation and explanation practices as they debated general rules that emerged from their everyday solutions. The teacher completed the "science and engineering concepts" column on the chart during this discussion. (20 minutes)	Connect Everyday Knowledge to Science Concepts

3	Students completed one last go-kart redesign, incorporating both everyday ideas and science concepts. Each group completed a final design challenge in front of classmates and discussed the ideas behind the final solutions. (20 minutes)	Redesign and Share Design Solutions
4–13	This instructional sequence was repeated for each of the design challenges.	

Reverse-Engineering Single-Point Rubric

Concerns Areas that need work	**Criteria** Standards for this task/challenge	**Advanced** Evidence of exceeding task standards
	Research Everyday Solutions Your everyday examples relate the assigned engineering task or project. You can describe how specific everyday examples can be used to guide your project design.	
	Construct and Test Everyday Solutions You apply specific ideas that you observed from everyday examples to your project. You test your design early and often, and identify failure points. You work to improve failure points with each trial and redesign effort.	
	Connect Everyday Knowledge to Related Science Concepts You are able to describe your everyday observations and ideas using science concepts and terms related to the project.	
	Describe Everyday and Scientific Ideas in Your Project You can connect your everyday examples to specific design solutions. You can describe your design solutions using related science terms and concepts.	
	Group Work and Behavior You work cooperatively with your group members. You use and manage materials safely and as instructed. You share constructive feedback with your classmates during design challenges and group discussions.	

Elementary Reading List

- *Papa's Mechanical Fish* by Candace Fleming
- *Those Darn Squirrels* by Adam Rubin
- *The Most Magnificent Thing* by Ashley Spires
- *What to Do With an Idea* by Kobi Yamada