



Drexel-SDP GK-12 ACTIVITY

Subject Area(s): Science & Technology

Associated Unit: Engineering a tower

Activity Title: “Tower Design”

Grade Level: 11th-12th

Time Required: 3 hours

Group Size: 3 students per group

Expendable Cost per Group: \$10

Summary

In this activity students are given the challenge of building a prototype of a transmission tower to win a city contract to construct the tower. Using the steps of engineering design, students must try to build the tallest tower while keeping a tight budget. At the end of the activity the best tower is chosen among the height, weight held, and remaining budget.

Engineering Connection

Engineers usually work in teams when they are presented with a new problem to solve and they must pay close attention to the criteria and specifications given in the task. They usually follow one of several versions of the engineering design process. Most of the time it involves a sketch of the design and then iterative process of constructing and

modifying until they meet the criteria. At the same time they are pressured to stay under a budget which can sometimes make or break a project.

Keywords

Engineering design, technical drawing

Educational Standards

- Science: 3.1 Unifying Themes: Models
- Science: 3.2 Inquiry and Design: Problem solving in technology
- Science: 3.4 Physical Science: Forces and Motion
- Science: 3.5 Technology Education: Physical Technologies
- Math: 2.2.11 Computation and Estimation
- Math: 2.3.8 Measurement and Estimation

Pre-Requisite Knowledge

Sketching a technical drawing which can be found in another module entitled “The blueprint of design.”

Learning Objectives

After this lesson, students will have gained the following experiences:

1. Use the engineering design process to solve a problem
2. Sketch a technical drawing
3. Manage a budget

Materials List

1. Paper
2. Scotch Tape
3. Duct Tape
4. Pencils
5. Rubber bands
6. Paper Clips
7. 3x5 note cards
8. Plastic Cups
9. Sand
10. Grid paper or engineering paper
11. Scissors
12. Rulers
13. Scale

Introduction / Motivation

The city wants to install an emergency broadcast system that will require new transmission towers. The city has set aside \$100,000 for these towers to be built and your engineering firm is interested in submitting a design to the city. Each interested

party must provide the city with a prototype of their design, a budget and a technical drawing of the design. The city will be looking for the tallest tower that can withstand the strong winds of our city. Additionally, the tower must be able to support a large weight on a platform at the tower's highest point. The city will look favorably on firms who stay under \$100 for the scaled down prototype. After reviewing the technical drawing and budget, the prototype will be judged based on the following formula:

$$\text{Score} = (\text{Height in cm}) * (\text{Weight supported in g})/10 + (\text{Amount under budget} * 10)$$

The company with the highest score will receive the contract for the construction of one tower.

Vocabulary / Definitions

Word	Definition
Technical drawing	A drawing used by engineers to show others their ideas for a design.
Design Process	A step by step methodology used by engineers to solve a problem.

Procedure Background

Although this activity is presented as a competition it is meant to take students through the engineering design process. The design process is an iterative process and is usually described with the following steps: 1) identifying the problem and the design requirements, 2) Brainstorming ideas, 3) Generating multiple possible solutions, 4) Selecting an approach and 5) Building and testing the prototype.

In this case, the city's challenge announcement explains the problem and the design requirements. The tower must be fairly tall and must remain stable even under windy conditions. It also must be economical for the city to build. All these factors are implemented into a formula which the students can use to make their prototypes. However, most students will be tempted to build the tallest tower without considering the budget.

The next step involves brainstorming. For students this will mean performing research online on possible structures given the materials provided.

Next step is generating multiple possible solutions. Using all the data gathered during the brainstorming phase students will need to sketch a technical drawing of their design ideas. They should draw their design from different orthogonal views and comment on what materials they would like to use.

Selecting an approach can also be called "decision time". Here students must pick their solution by considering the budget constraints and the original problem statement. Here

they can make adjustments to their technical drawing and make their proposed budget. These two are deliverables they will have to turn in during the activity.

Finally, building and testing the prototype. This is possibly the part that students will enjoy the most but after the testing phase it gives students a chance to make adjustments and improvements.

Before the Activity

Establish a price list of materials keeping in mind an imaginary spending budget of \$100 to complete their prototype. A recommended price list is as follows:

Material	Price
1 sheet of paper	\$5
10 cm scotch tape	\$10
10 cm duct tape	\$15
1 Paper Clip	\$3
1 rubber band	\$2
1 wooden pencil	\$10

With the Students

1. Students are given the prompt, the price of materials and the judging criteria. At this time students should be reminded that the top of the tower should have a platform (note card) in place to hold the plastic cups.
2. Before receiving any of the materials, students must draw a proper technical drawing of their design and come up with a list of materials they would like to purchase. Their drawing should at least have a top view and a side view. This process could take about 1 hour.
3. Students can now purchase their materials as long as they stay under budget.
4. They have 1 hour to build their structures. They should closely match their engineering technical drawing (Figure 1).
5. Next comes the judging part. All students should place their towers side by side along a lab bench or table and have one representative standing by their prototype.
6. Fill cups of sand halfway and measure their weight on a scale so the weight of each cup is relatively the same.
7. Measure the height of the tower from the table top to the platform (note card)
8. Stack the cups one by one on top of the tower platform until the tower falls or breaks (Figure 2).

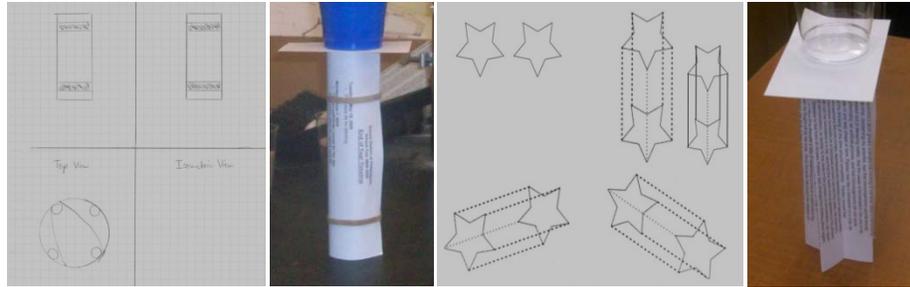


Figure 1: Examples of two engineering towers built after first sketching a technical drawing.



Figure 2: Cups of sand stacked on top of tower platform.

9. Establish a maximum weight of sand that you are willing to add and if the tower succeeds record the weight and move on to the next tower. Typically we have used a max between 2000 – 3000 grams.
10. When finished have the students clean up the table tops while you calculate the winner based on tower height, weight held, and remaining money.

Troubleshooting Tips

Have a broom and duster handy as the sand will go everywhere.

Investigating Questions

1. From all of the towers built what type of structural features worked best to maintain tower stability?
2. How did the technical drawing help you build your prototype?
3. What would you have done differently with the budget and supplies?

Assessment

Pre-Activity Assessment

Title: Online brainstorm

Each group will go online to find images of structures they think are strong, sturdy and tall. They will then make a list of characteristics they would like to incorporate into their prototype.

Activity Embedded Assessment

Title: Deliverables

During the activity, students are responsible for 3 deliverables: 1) a sketch of their design following the technical drawing specifications, 2) a proposed budget and a final budget and 3) their prototype design.

Post-Activity Assessment

Title: Class discussion

The class will first reread the challenge as it was presented and then come to a consensus on defining the problem, the criteria and constraints. Then the class will discuss the structural characteristics of the tallest tower that witheld the most weight. Also, students will discuss what role the budget played in their design and looking back what changes would they have made in their spending habits.

References

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