Mission Control Lesson Plan:
Designing and Building a Tower as a Team

Location of Mission Control

Gateway to Space

Overview of Mission Control

Mission Control is a game that was designed to convey to audiences of all ages, in a fun and engaging way, some of the problems that can arise during a mission and how together as a team they must solve them. Mission Control is a group of ground personnel who manage aerospace flights from before liftoff to landing. So much can go wrong before and during a space flight. The flight controllers and other personnel in Mission Control must work together as a team to solve the problems in order to conduct a safe and successful flight. Most of the issues and flight controller characters in the game are either factual or based on real terminology. A badge is awarded upon successful completion of this game.

Lesson Overview

This lesson plan/unit could be used independently or to prepare for (or to extend the learning after) a visit to Spaceport America. It can be used by teachers or parents wishing to make the Spaceport visit a richer learning experience (for everyone!).

Just as Mission Control personnel must work together to launch and safely return a spacecraft, in this hands-on activity, students will work cooperatively as a team to solve an engineering problem – building a tower with a minimum height that will support a given weight for a given amount of time using the least amount of money. This design problem is not unlike what engineers tackled when thinking about how to build a launch platform for vertical launch rockets. Students will also work within real world parameters, (i.e., a budget, efficient use of raw materials, and a deadline) to complete their task.

Each team must complete this task…build a tower that is:

- at least 51 centimeters (≈ 20 inches) tall
- can support three standard bricks (≈ 4.5 pounds each)
- for at least eight seconds
- using the least amount of money

Extra points can be awarded to the team who has the tallest tower or uses the least amount of money, can support the bricks the longest, or any other goal you can think of as long as the main engineering problem is achieved.

Construction costs are determined as follows:

1. $1 for each index card used (= raw materials used AND discarded)
2. $1 for each staple used (= raw materials used AND discarded)
3. $1 for each fold they make in the cards (= construction/production costs)

Grade Level

Grades 4 through 12.

Learning Objectives

Students will:

1. Work together cooperatively to accomplish a task
2. Gather insight about structures by looking at pictures
3. Apply basic science and engineering laws to construction of their tower
4. Use verbal, non-verbal, and written communication
5. Account for their spending

Assessment

While “success” may seem to be awarded to the team that is able to successfully overcome the engineering problem, all students who participate should achieve the learning objectives. Re-running the experiment one or more times may yield that much more learning and send the important message that you don’t always find the best answers the first time!

Required Materials

For each team:

- 3” x 5” cards (unlimited supply)
- Stapler and staples
- Flat topped level table to build on

For the teacher:

- Three standard bricks (or hefty books of the same weight)
- Measuring stick or tape measure
- Clock with a second hand
- Internet connection and printer (to print pictures)

Time Required

One class period for the task. More if you want to extend and do write-ups. (Recommended.)

Step-By-Step Procedures

1. BEFORE CLASS: Print some pictures of tall, load-bearing structures such as radio towers, bridges, and pyramids. Post the pictures on a bulletin board or tape to white board for students to study and discuss during the lesson. (A list of suggested links where you can gather good pictures is located at the end of this lesson plan.)
2. Introduce the engineering problem to the students as stated above in the Lesson Overview.
3. Divide the students into groups of four. Assign (or let them assign) roles. Suggested roles are:
   - Project Manager – Keeps track of time and decides next step if team gets stuck.
   - Construction Foreman – Obtains and keeps track of all raw materials (cards and staples) as well as number of folds and reports information to the Accountant.
   - Engineer – Makes informed design recommendations based on research and discussion of all team members.
   - Accountant – Keeps track of the dollars spent and reminds the team of the current expenditures at all times.
4. Distribute the materials. Put the 3” x 5” cards in a central location in the classroom. (Suggestion: Divide the cards into stacks of 20 beforehand and only let a team take one stack of 20 at a time.) Put a stapler full of staples on each team’s table.
5. Start the clock. It is suggested that you limit the time for the task to 18 minutes for middle and high school students. You may wish to extend the time to 25 minutes for younger students whose fine motor skills may not be as well developed. (Links are included in the Other Resources section for applications that will allow you to display the time left with a computer and projector.)
6. *Before they begin building*, encourage students to look at the pictures on the board to gain insight about what shapes might be best to use *before* they begin building. Encourage them to discuss their ideas with their team members and decide how they might apply this information to this task.
7. Watch the clock. At the end of the given time, students should not be allowed to touch their construction.
8. Take the bricks to each team’s table. Measure and record the height of their tower, record the dollars spent, and then test to see if their tower will hold the bricks for eight seconds. Record results.

9. Discuss what they learned. Ask what they might do different if they repeated the lesson a second time.
10. Allow time (possibly future class periods or for homework) for each student/team to recap what they have done and do a written or oral report. Criteria for this might include:
    - Write a statement of the engineering problem.
    - Draw a scale picture of your tower. Label all dimensions.
    - Write a description of your insights gained from your initial research (looking at the pictures and any prior knowledge you might have).
    - Write a description of the approach you intended to take.
    - Write a description of the approach you actually ended up taking. How did you make the tower the required height? In other words, how many index cards did you use to meet the height requirement? How were the cards configured?
    - Describe how you used folds in your design to achieve strength and stability. What else did you incorporate into your design to achieve this?
    - How did you "cut costs" without sacrificing stability?
    - Describe what part of your design was as successful as you predicted and what part was not.
    - Report your costs (including any discarded materials), your results, and your lessons learned.
    - How would you modify your design based on what you learned by what your team and other teams discovered?
    - How well did you work together toward the task?

Alignment to Next Generation Science Standards

Next Generation Science Standards align well with this lesson. Specifically,

- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- 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.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Other Resources:

- https://www.youtube.com/watch?v=KiP8SBkjtU8 – Watch these high school physics students report out their solution to this engineering problem (Note: different height goal) to gain a good understanding of what can be done. This is a good video to show your students before they do a report but NOT before they begin the task.
- https://www.youtube.com/watch?v=Ik41Fe1WK6Q – A university professor shares a similar design challenge and the experiences of his freshman students.
- To display the countdown time using a computer and projector, try these links.
    - For Shareware Windows applications:
        - http://www.timeleft.info/
        - http://www.orzeszek.org/blog/2009/08/21/simple-countdown-timer-for-windows/
    - For a Mac:
        - http://www.baldgeeks.com/3-2-1.htm
- Picture of radio towers:
    - Simply print the picture on this page. http://www.gordonmarcy.com/wp-content/uploads/2009/05/radio-towers.jpg
    - Simply print the picture on this page. http://www.fallingpixel.com/products/14941/mains/000-3d-model-RadioTower_thumbnail01.JPG
    - You can also see yet another engineering design problem and see how others discussed the solution(s). http://www.starquestclub.com/forum/index.php?showtopic=117130
- Picture of bridges:

- This page includes both good photographs and structural drawings of a simple truss bridge built before there were computers and good engineering research. http://faculty.tcc.fl.edu/scma/carrj/Bridges/oldnorth.html
- Good picture of a continuous truss bridge: http://en.wikipedia.org/wiki/Kingston-Rhinecliff_Bridge

- Picture of tall buildings:
  - *Drawing* of tallest ten buildings in the world: http://laurencebradford.com/wp-content/uploads/2013/11/tallest-buildings-world.jpg
  - This is a compilation of *photos* of the ten tall buildings. http://i.dailymail.co.uk/i/pix/2014/07/10/article-2687728-1F8DE69100000578-153_964x578.jpg
  - Pictures of the ancient pyramids at Giza: http://en.wikipedia.org/wiki/File:All_Gizah_Pyramids.jpg
  - Aerial view of the pyramids at Giza: http://en.wikipedia.org/wiki/Egyptian_pyramids#mediaviewer/File:Giza-pyramids.JPG
  - STS-134 Mobile Launch Platform http://commons.wikimedia.org/wiki/File:STS-134_Mobile_Launcher_Platform_with_two_Solid_Rocket_Boosters.jpg