

Engineering Design Challenge Notebook

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Table of Contents

- Midterm- [Research and Planning](#) the Engineering Task
- [Brainstorming](#)
- [Design](#) and Build
- [Test and Evaluate](#)
- [Redesign](#)
- [Share Solution](#)
- [Student Work](#)
- [References](#)

Phase 1- Research and Planning

I will preface this notebook by stating that the project I had originally planned during the midterm was not able to fit into my Earth Science class in time for the final, due to unforeseen circumstances. However, I started coaching my school's Science Olympiad team (partially due to my experience in this class) which requires a TON of engineering. In Science Olympiad, students compete in 23 events, around 10 of which require engineering design. These events include building a non-digital clock, a trajectory device (aka catapult), a bottle rocket parachute, a WiFi router, a salinity and conductivity detector, a bridge, and more. My Science Olympiad team meets weekly after school, and I have been able to do several short engineering design challenges with them, including this catapult design challenge.

I decided on this challenge for several reasons, based on the skills needed for the Science Olympiad competition. Students need to design a trajectory (catapult) with limited materials, and collect data on how different projectiles work from their design. In the competition, students have 3 trials to launch a chosen projectile at a target. I therefore modeled this design challenge after what they needed to do for the Science Olympiad competition.

Because I still want to do the larger engineering project with my Earth Science class (water filter design), I decided to use a few class periods before the project to do the catapult design challenge with them, to get them more familiar with the engineering design process. One thing that I am finding as I incorporate more engineering in my classes is that students need small successes with the engineering design process and practice with teamwork, before doing the larger challenges. So I really liked this activity for that.

1. **Big Concept-** Projectile Launch and Catapults

2. **Standards Addressed:** NGSS Science and Engineering Practices

- Develop and Use Models
- Designing Solutions
- Analyze and Interpret Data

3. **Problem Solving Skills-** Students will solve a moderately structured problem in this activity; materials and basic parameters will be provided, but there are multiple paths to a working solution. In this project students will need to practice identifying and explaining constraints, brainstorming ideas, designing and building prototypes, testing prototypes by collecting data, analyzing prototype data, revising their prototype based on data, and coming up with a final evaluation of their model. This will in turn require some collaboration skills, which students in my classroom are working on at all times. In terms of necessary declarative knowledge, students will need to form a basic understanding of potential and kinetic energy, motion, and how a projectile works.

4. **Content Knowledge Addressed-** From NYSSLS Disciplinary Core Ideas

- **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.
- **Science & Engineering Practice:** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

5. **Objectives-** Students will be able to

- Rapidly prototype and test a design
- Use a set of constraints and parameters to develop, test, and revise a prototype
- Work collaboratively with a team
- Give constructive feedback to other groups based on the data their prototypes produced

6. **Possible Activities**

- Popsicle Stick Catapult- https://www.teachengineering.org/sprinkles/view/cub_catapult_discoveryplace.org/stay-at-home-science/diy-catapult
- Wooden Catapult- <http://teachers.egfi-k12.org/activity-build-a-simple-catapult/>
- Wooden Catapult- <https://static.nsta.org/pdfs/store/pb152x4web.pdf>

7. **Best Activity-** The goal for this activity is to build student confidence and have them go through the engineering design process as a group, before completing a larger and much more challenging science and engineering task. For this reason, I really liked a combination of the 3 challenges above, with more constraints to make it a bit more appropriate for high school.

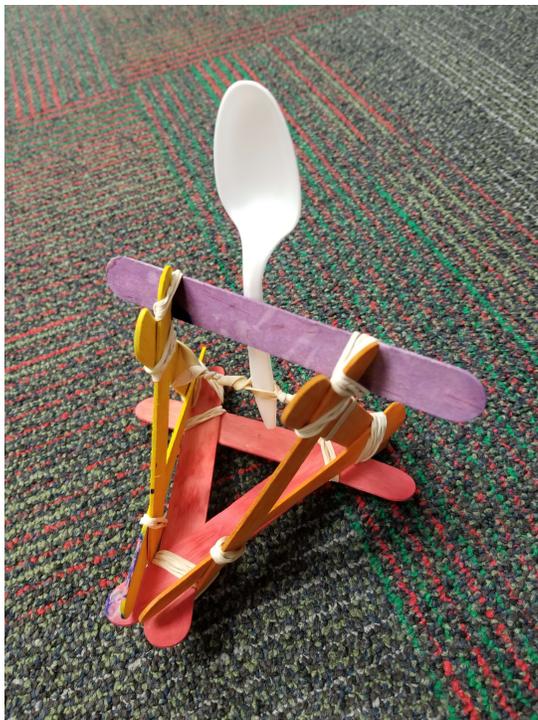
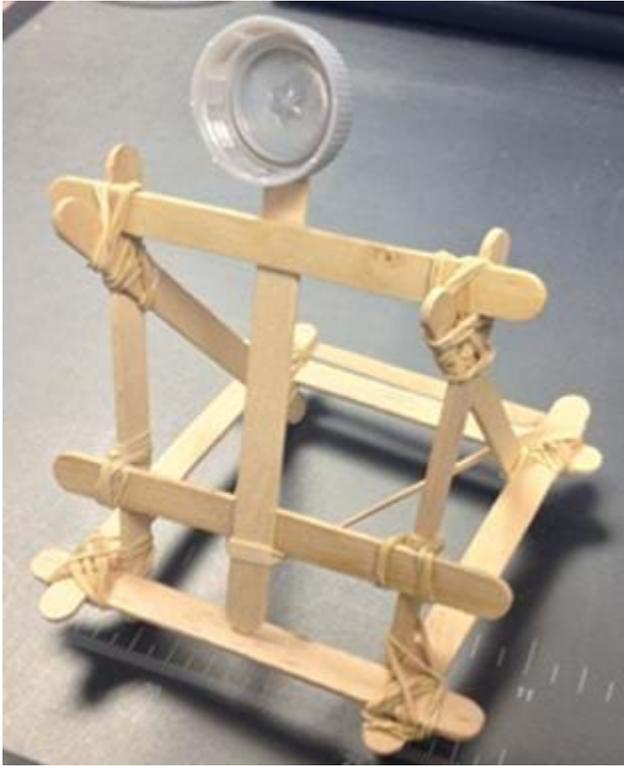
Goal: Design a catapult that can hit a target placed on the floor 2m away, as many times as possible (3 tries).

Parameters: 20 minutes to design, 5 minutes to test and revise

Materials: 15 rubber bands, 15 popsicle sticks, 1 spoon, choice of projectiles: smarties, Ping Pong balls, or marbles

Brainstorming Solutions:

When starting this design challenge, I researched several possible solutions to the problem, based on those who had done the engineering challenge before. This is what students will need to do for science olympiad as well; many of their design and engineering challenges are things that have been done before, and students have to design and refine the best possible model within the parameters, so I wanted to use the same approach. From my research, I identified several different ways to design the catapult with the parameters given. The goal for my students will be to hit a target about a meter away, posted on the floor. I evaluated some possible design solutions



Design:

After playing around with the different designs and my materials, I decided to create the simplest possible model first, so that I could better understand the relationships between the launcher, the projectile, and the angle of launch. I anticipated starting simple would be the best way for me to work with students on their later models. In my design, I tried a combination of stacked sticks at the base, with the launcher attached to a stick sandwiched between the stack of sticks. I began testing the different combinations of # of popsicle sticks on the base, which affected the angle of the spoon launcher, as well as how far out the popsicle stick base attached to the spoon, which also affected the angle. I played with several different combinations until I was ready to test.



Test and Evaluate:

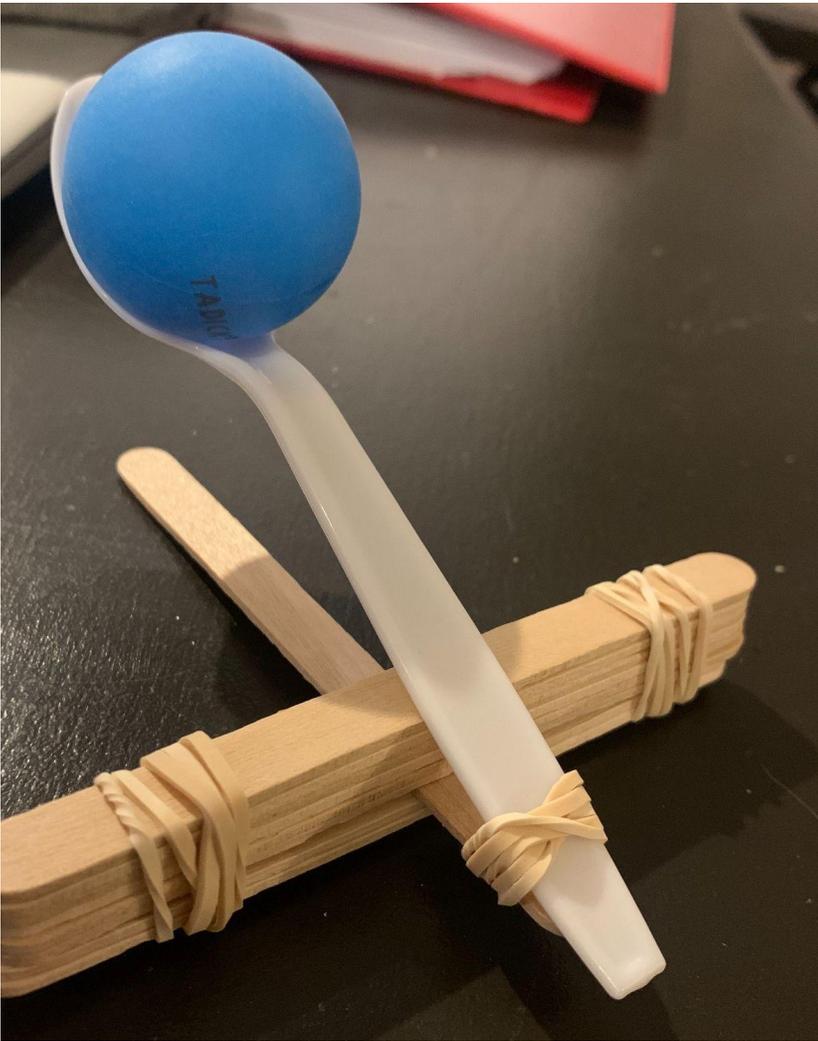
I tested my spoon catapult in several ways. First I evaluated the height of the projectile launched and the distance the projectile reached. Because for the design challenge students would be a target 2m away

	Projectile Height	Projectile Distance
Average of 5 trials	8.2 cm	10.5 cm

Redesign:

Because the goal for this project was to hit a target 2m away, I needed to redesign my catapult to allow for more launch of the ping pong ball. I started to stack on more popsicle sticks to increase this angle. In my new design, I had a stack of 8 sticks for the base.

	Projectile Height	Projectile Distance
Average of 5 trials	30cm	102 cm



****in progress**

Share Solution:

In this activity with students, student groups:

- Tested their catapult designs in front of the class
- Each group was given three tries to
- Students then gave each other feedback on their designs, and were invited to incorporate feedback into a new design model.

The rationale for this model of sharing solutions is because for both Science Olympiad and my Earth Science project for later, students will have to share their design with a larger audience, both for feedback and for final evaluation. By using this in the small engineering task here, students become more comfortable giving and receiving constructive feedback, as well as are presented with the accountability of having to produce something (although it does not have to work!) during their 25 minute time frame.

Student Work:

The students produced a variety of models for this task, some of which are shown below.



Student Design #1

References:

- *2-Week Unit Plan Sources (Engineering - Catapults) Collection* | NSTA. (2021). Nsta.org. https://my.nsta.org/collection/tvfoZU!plus!twWc_E
- Design a Catapult (for Informal Learning). (2021, November 11). TeachEngineering.org. https://www.teachengineering.org/sprinkles/view/cub_catapult
- *Trajectory* | Science Olympiad. (2021). Soinc.org. <https://www.soinc.org/trajectory-c>