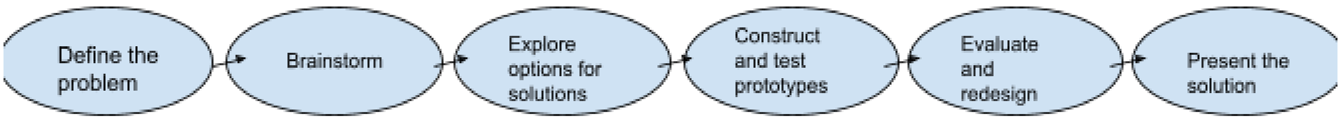
Patricia Mannion
The E in STEM
Major Project: Engineering Design Challenge
Phase II

# "Crafting Cranes and Engineers"

Phase II: Implementation

The engineering design process that I selected was a compilation of the engineering designs that I highlighted in the Comparative Analysis of Design Models assignment. It is also a modification of the Project Lead the Way program.
Essentially, the process is distilled into the following six steps:




I will be meeting with the Engineering Club on the following dates:

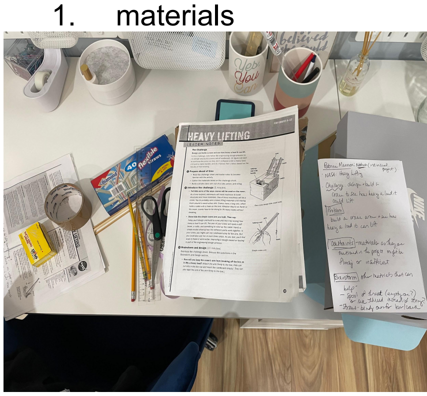
| | |
|---|---|
| 9/28/23 | Introduce and choose the project |
| 10/5/23 | Brainstorm and discuss constraints and sketch |
| 10/18/23 | Build and test |
| 11/2/23 | Redesign and present |

While the original sequence of events was planned with good intentions, calendars and schedules started to prove unreliable, so I took a different approach and decided to try the project on my own first, and then follow up with the engineering club.

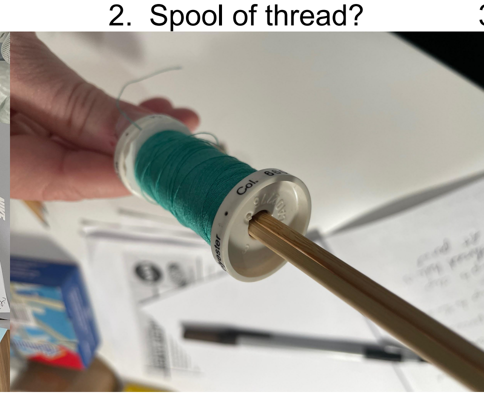
**My Own Implementation:**
[Patty Mannion Engineering Notebook]

Below are some photos of my original engineering project:

1. materials




2. Spool of thread?



3. Ribbon for take-up reel?

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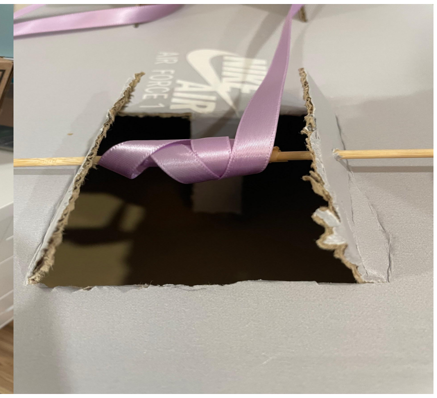
4. Pencil and ribbon

5. Pencil and ribbon reel

6. The new reel (Skewer)



7. Connecting the basket

8. The structure with largest payload (two charging bloc

Links to videos of projects:
[Original Take Up Reel (Spool)]
[Better Take Up Reel (Second Design)]

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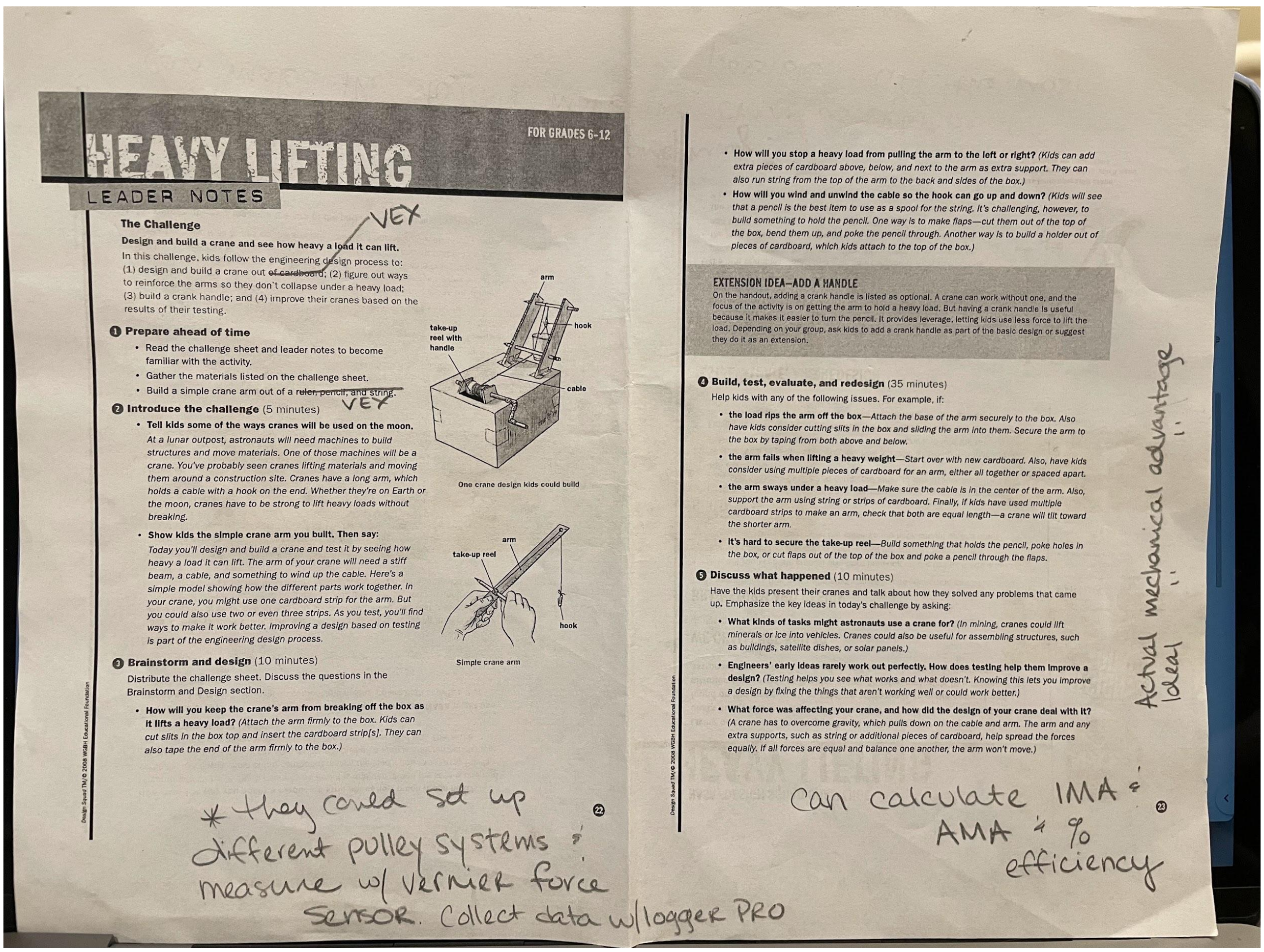
**Engineering Club Implementation:**

After I did my design project, I met with the Engineering Club to have them do the project. Several groups worked on building a crane with VEX equipment, which is more like an erector set. The students had engineering experience, and as a result were more inclined to follow their own process rather than the process I was interested in using.

Below are some photos that were gathered over the four meetings:

ALL GOOD INTENTIONS AND LOFTY GOALS!



# HEAVY LIFTING

FOR GRADES 6–12

LEADER NOTES

**The Challenge**

**Design and build a crane and see how heavy a load it can lift.**

In this challenge, kids follow the engineering design process to: (1) design and build a crane out ~~of cardboard~~ VEX; (2) figure out ways to reinforce the arms so they don't collapse under a heavy load; (3) build a crank handle; and (4) improve their cranes based on the results of their testing.

**1 Prepare ahead of time**

- Read the challenge sheet and leader notes to become familiar with the activity.
- Gather the materials listed on the challenge sheet.
- Build a simple crane arm out of a ~~ruler, pencil, and string.~~ VEX

**2 Introduce the challenge** (5 minutes)

- **Tell kids some of the ways cranes will be used on the moon.** *At a lunar outpost, astronauts will need machines to build structures and move materials. One of those machines will be a crane. You've probably seen cranes lifting materials and moving them around a construction site. Cranes have a long arm, which holds a cable with a hook on the end. Whether they're on Earth or the moon, cranes have to be strong to lift heavy loads without breaking.*
- **Show kids the simple crane arm you built. Then say:** *Today you'll design and build a crane and test it by seeing how heavy a load it can lift. The arm of your crane will need a stiff beam, a cable, and something to wind up the cable. Here's a simple model showing how the different parts work together. In your crane, you might use one cardboard strip for the arm. But you could also use two or even three strips. As you test, you'll find ways to make it work better. Improving a design based on testing is part of the engineering design process.*


One crane design kids could build


Simple crane arm

**3 Brainstorm and design** (10 minutes)

Distribute the challenge sheet. Discuss the questions in the Brainstorm and Design section.

- **How will you keep the crane's arm from breaking off the box as it lifts a heavy load?** *(Attach the arm firmly to the box. Kids can cut slits in the box top and insert the cardboard strip[s]. They can also tape the end of the arm firmly to the box.)*

* they could set up different pulley systems & measure w/ Vernier force sensor. Collect data w/ logger PRO

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- **How will you stop a heavy load from pulling the arm to the left or right?** *(Kids can add extra pieces of cardboard above, below, and next to the arm as extra support. They can also run string from the top of the arm to the back and sides of the box.)*
- **How will you wind and unwind the cable so the hook can go up and down?** *(Kids will see that a pencil is the best item to use as a spool for the string. It's challenging, however, to build something to hold the pencil. One way is to make flaps—cut them out of the top of the box, bend them up, and poke the pencil through. Another way is to build a holder out of pieces of cardboard, which kids attach to the top of the box.)*

**EXTENSION IDEA—ADD A HANDLE**

On the handout, adding a crank handle is listed as optional. A crane can work without one, and the focus of the activity is on getting the arm to hold a heavy load. But having a crank handle is useful because it makes it easier to turn the pencil. It provides leverage, letting kids use less force to lift the load. Depending on your group, ask kids to add a crank handle as part of the basic design or suggest they do it as an extension.

**4 Build, test, evaluate, and redesign** (35 minutes)

Help kids with any of the following issues. For example, if:

- **the load rips the arm off the box**—*Attach the base of the arm securely to the box. Also have kids consider cutting slits in the box and sliding the arm into them. Secure the arm to the box by taping from both above and below.*
- **the arm fails when lifting a heavy weight**—*Start over with new cardboard. Also, have kids consider using multiple pieces of cardboard for an arm, either all together or spaced apart.*
- **the arm sways under a heavy load**—*Make sure the cable is in the center of the arm. Also, support the arm using string or strips of cardboard. Finally, if kids have used multiple cardboard strips to make an arm, check that both are equal length—a crane will tilt toward the shorter arm.*
- **It's hard to secure the take-up reel**—*Build something that holds the pencil, poke holes in the box, or cut flaps out of the top of the box and poke a pencil through the flaps.*

**5 Discuss what happened** (10 minutes)

Have the kids present their cranes and talk about how they solved any problems that came up. Emphasize the key ideas in today's challenge by asking:

- **What kinds of tasks might astronauts use a crane for?** *(In mining, cranes could lift minerals or ice into vehicles. Cranes could also be useful for assembling structures, such as buildings, satellite dishes, or solar panels.)*
- **Engineers' early ideas rarely work out perfectly. How does testing help them improve a design?** *(Testing helps you see what works and what doesn't. Knowing this lets you improve a design by fixing the things that aren't working well or could work better.)*
- **What force was affecting your crane, and how did the design of your crane deal with it?** *(A crane has to overcome gravity, which pulls down on the cable and arm. The arm and any extra supports, such as string or additional pieces of cardboard, help spread the forces equally. If all forces are equal and balance one another, the arm won't move.)*

Actual mechanical advantage :: Ideal ::

Can calculate IMA & AMA & % efficiency

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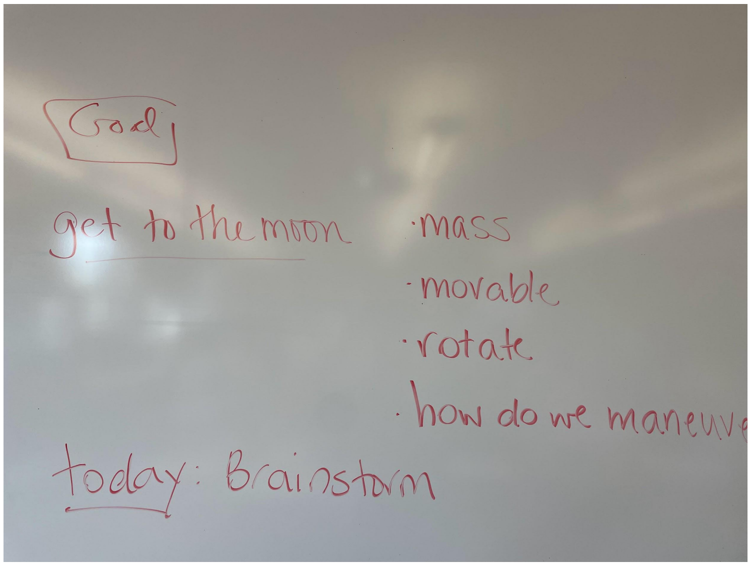
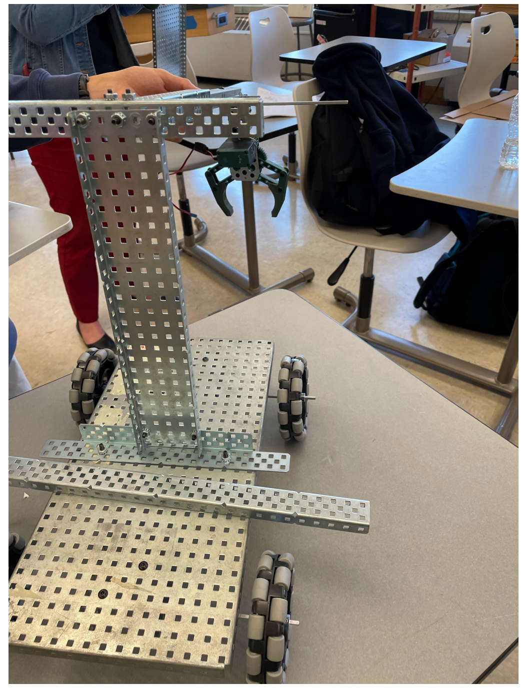
DISCUSSING CONSTRAINTS

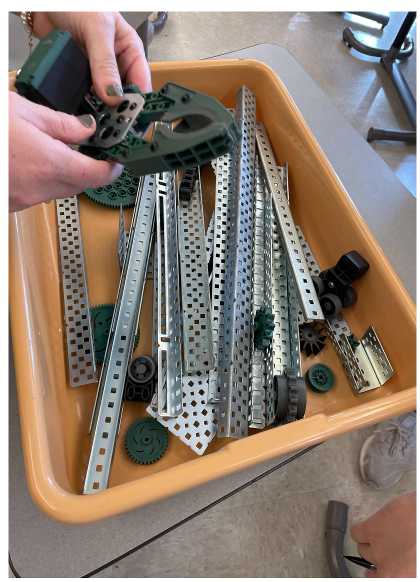



BUILDING



A PROTOTYPE

ASSESSING MASTERIALS



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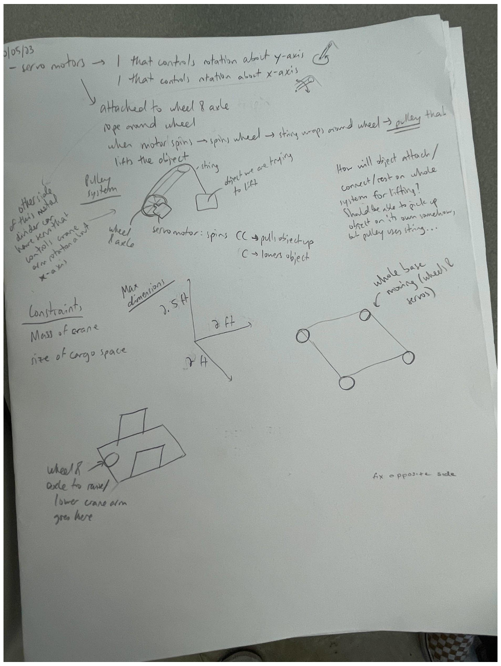
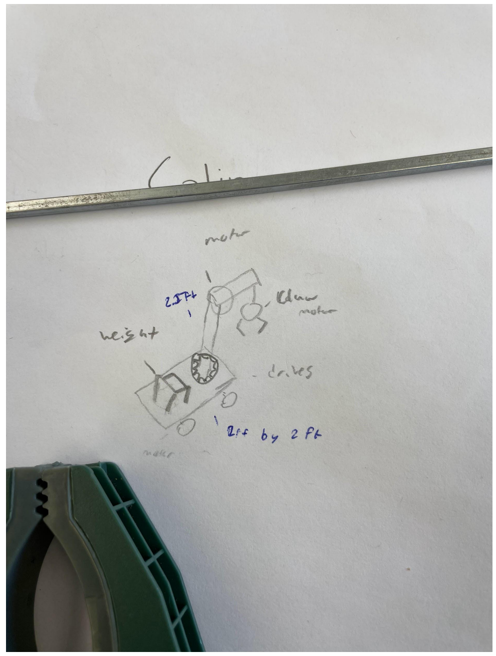
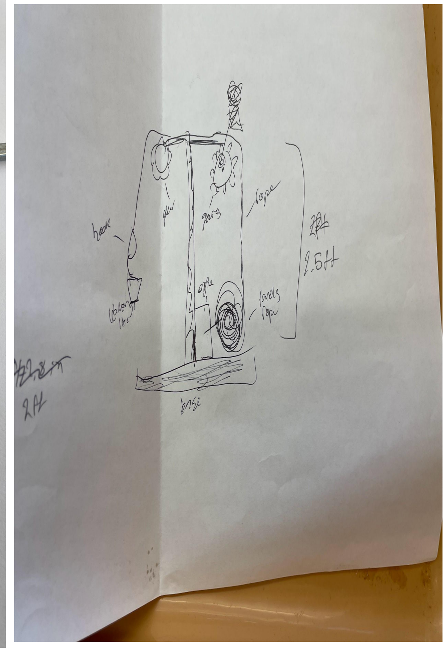
THREE DIFFERENT DESIGN NOTEBOOKS








Links to videos of final projects:
[The One with the Wrench]()
[The One with the Claw]()

Reflection:

a) When I did my own version of the design challenge, I thought so  many things went well. The process played out exactly the way it was supposed to. I gathered the materials and then started to brainstorm a list of other items that might work. Then I went about sketching and building, making adjustments along the way as the spool of ribbon was too loose for the pencil and I started to use tape to try and tighten the grip. Eventually that fix turned out to be short lived and I had to try a new design with a skewer and ribbon.

   When I worked with the students, one group (the one with the wrench) had the same thing happen, which I thought was interesting. They had a 3-D printed take up reel with a narrower diameter so it fit more tightly and then it worked.

   All in all, I thought the process unfolded in the steps with a consistent revisiting of the design and materials and redesigning,

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b) I wouldn't say that working with the Engineering Club didn't go well, but it wasn't ideal. The moderator and I met and initially we had very lofty goals for the project. They weren't working with the household items that I was, but they had more sophisticated equipment so their process and designs were different. The level of commitment, while motivated by a pizza party, was inconsistent because this wasn't for a class and the students have several other commitments.

c) The following standards were addressed:

| | |
|---|---|
| MS-ETS 1-1. | 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-ETS 1-2. | Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. |
| MS-ETS 1-3. | 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-ETS 1-4. | 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. |

d) The engineering design process in this project helped teach the math and science concepts in several ways. These include an understanding of the laws of motion, understanding angles for optimal lift, and determining the length of the string or diameter of the take-up reel.

e) I thought the design process was absolutely appropriate for my project. The students, however, have experience with engineering already. If I did this again with experienced students, I would change my expectations and I would follow their lead and allow them to decide which process to follow. If I was doing this on my own with new engineering students, I would stay with the challenge as originally designed and use the process that I outlined. I think it was a good, solid way to introduce the design process and make something fun.

f) I think the NASA challenge is designed well and pretty easy to implement with students. I would have to try with a different group of less experienced learners before I would be able to come up with some ways to improve it, in all honesty.