

Major Project: Engineering Design Challenge

Erin Treder

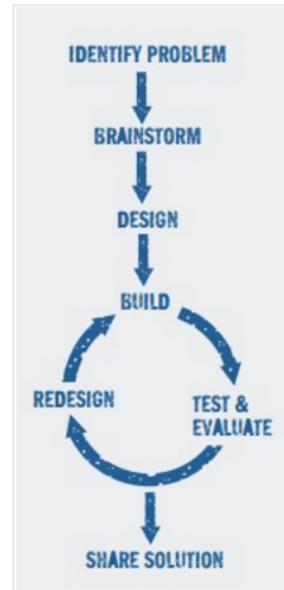
NASA Endeavor

The E in STEM: Meaningful Content for Engineering

This NASA and Design Squad Challenge: Launch It, will be used in a High School Conceptual Physics course.

Phase II:

1. The engineering design process that I chose to use during this project was the *Design Squad* process. I determined that using the process that the activity was written around would be a smooth implementation for students during their project. Even though many of the design processes have similar elements and ideas throughout, I thought the students would have a better time following the process if we went with the one the activity was designed around. The big thing I want students to get from the process is how cyclic it is. I want students to see that they can change plans and go back to different parts of the process as needed and the Design Squad version does that. To the right is a copy of the process as defined by the Design Squad.
2. For implementation of this activity in my classroom, I would plan four days for this activity.
 - a. Day one: identifying the problem, brainstorm, and design
 - b. Day two: build, test, and evaluate
 - c. Day three: redesign and share the solution
 - d. Day four: a flex day so that if/when the other days run long, we have the extra time
3. When I performed this activity with a small group of students (three), we worked on it for 2.5 hours. This includes all the engineering notebook write-ups, building, and testing of our rockets. The students were of different ages and will be going into fourth, sixth, and seventh grade in the fall.



I began by having the students look at the design challenge. I made some modifications to the supply list and thus the final product. I did not want to use one-time use straws so we could be a little more environmentally conscious; instead we used stainless steel straws to launch our rockets. We also made our rockets entirely out of paper, tape, and play-dough. The other modification I made was to have the students launch their rocket by blowing into the straw instead of using balloons. At our school we are not allowed to use balloons in any activity because there are so many latex allergies, so I needed another way to launch the rockets and blowing into the straw was a great alternative.

After we looked at the challenge, I had the students determine what they wanted their rocket to accomplish. We had a discussion about the things that we could measure from our rockets and then picked the best one. They came up with a list of three things that we could measure, how high the rocket went, how far the rocket went and how long the rocket was in the air. They decided to go with measuring how far the rocket went because they wisely thought we would have some difficulty measuring how high they went and they didn't want to time the rockets.

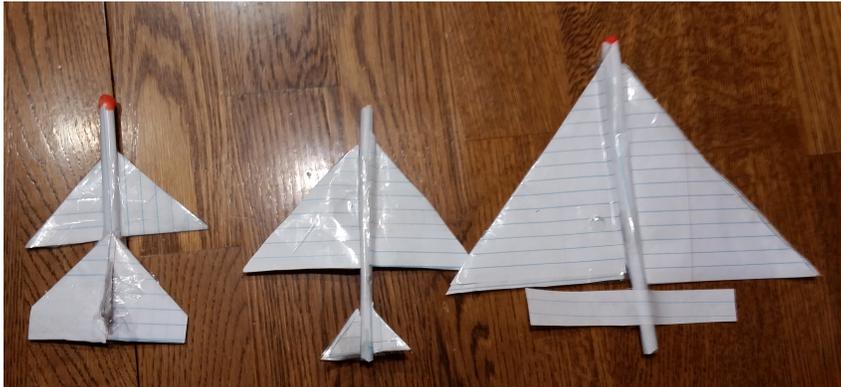
Next, we went into the brainstorming and designing portion of the process. Now that the students had identified the problem and what they wanted their rocket to do, they begin to think about possible solutions. These two steps kind of blended together as the students were discussing and drawing pictures for their potential solutions. Once they had created some initial designs for their rockets, they had to determine the best one. They all chose their final design based on rockets or airplanes that they had seen before.

After that it was on to the build portion. During this portion the students each built the rocket that they had chosen using only paper, tape, and play-dough to seal the rocket. Once each student was done, they immediately jumped into the testing phase. They would take a few practice launches, and then come back and change their design. This happened many times until each student had a rocket that they were satisfied with.

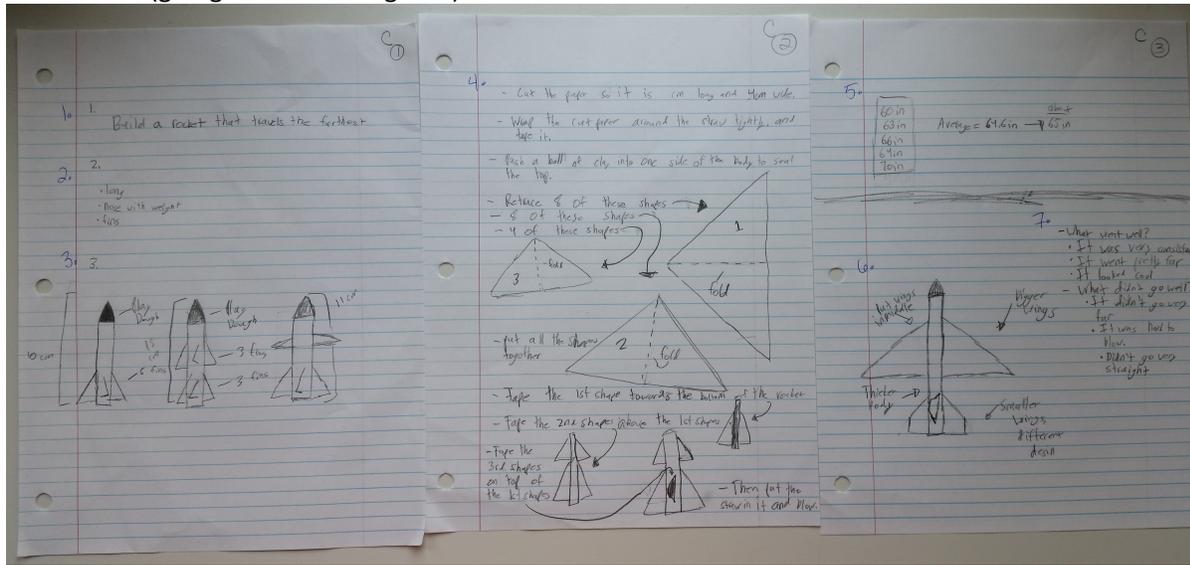
We then took each rocket and launched them a number of times to get data. We had plans to launch each rocket ten times (as chosen by the students), but since they were made of paper, we could only get about five launches from each rocket. As we were launching the rockets multiple times, the students asked what we were going to do with all of these numbers. So I turned it around to them and asked what they thought we should do with the data. Each student proudly said that we should average them, so that is what we did. Each student calculated the average distance that their rocket flew and reported that number.

After we had gathered the data and calculated the average. I asked the students what changes they would still make to the rocket that they created and they recorded that in their notebooks. I then asked them to write down what they would tell someone who was not here about their experience and rocket design. These responses were also recorded in their notebooks.

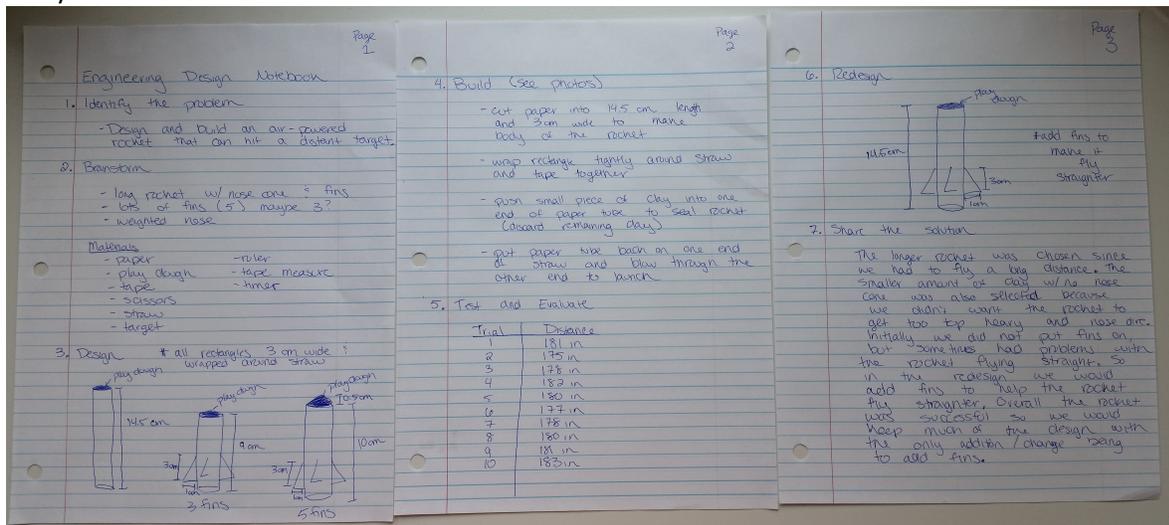
Here is an image of their finished rockets.



c. Student C (going into seventh grade)



d. Myself



5. During this process we had many failures and successes too. Which is exactly what you want out of an engineering design process. There were also difficulties and issues that we needed to address during the process. The biggest difficulty was using paper as the primary material for our rocket. We found that the paper broke down easily and made the rockets vulnerable to water damage, or more accurately, spit build up when launching. This did not allow us to get the ten data points for each rocket as we had intended. Instead, we had five data points for each one.

a. One thing that went well during the challenge was how engaged the students were. During the entire process they were actively involved and talking about their rockets. I was worried that during the summer they would not want to write out all of their steps in the engineering notebook, but the students were happy to keep track of their progress.

Another thing that went well was that the students really wanted to make the best rocket possible. They were doing everything they could think of to perfect and master their design. Their competitive nature came out during this process as well, because they all wanted to win and have the best rocket.

A third thing that went well was how much thought the students put into extraneous variables. They were very concerned about how much the wind outside would affect their rockets. They also wanted to make sure they were using the correct material and would ask if cardboard or other things would work better. The fins and nose cone were another topic of question, they all wanted to make sure they had the appropriate shape; otherwise, the rocket would not work as well. The students were thinking of all kinds of extraneous variables without my needing to prompt or push them to think about those factors.

- b. There were some things that did not go well. One was mentioned above, that paper is very susceptible to damage when launching. Another thing was making sure there were no leaks in the rocket. Since we wrapped paper around the straw to make the body of the rocket, we had to make sure that there was a good seal otherwise the rocket would not fly. A couple times we needed to restart our build because the body was not sealed tightly enough to launch the rocket. While there was a little frustration about this, the students always handled it well and would do what was necessary to build a rocket that would launch.
- c. The topics and standards that were covered are as follows:
 - i. Measurement: CCSS.MATH.CONTENT.2.MD.A.1: Measure the length of an object by selecting and using the appropriate tools such as rulers, yard sticks, meter sticks, and measuring tape.
 - ii. Calculate the average: CCSS.MATH.CONTENT.5.NBT.B.5: Fluently multiply multi-digit whole numbers using the standard algorithm. And CCSS.MATH.CONTENT.5.NBT.B.6: Find whole-number quotients of whole numbers up to four-digit dividends and two digit divisors, using strategies based on place value, the properties and operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.
 - iii. Forces and Motion: K-PS2-1 Motion and Stability: Forces and Interactions: Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. And 3-PS2-2 Motion and Stability: Forces and Interactions: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
- d. The engineering design process was great in helping teach the science and math concepts. As the students were working through the design process, the math and science just fell into place. Whether the students were asking questions like what to do with the data they gathered for their rocket, or testing a design and asking how they

can adjust to make the rocket better, the students were not only coming up with, but also answering the science and math questions themselves. One such example was when a student came to me after they tested their rocket and asked how they could prevent it from spinning when launched. I asked them to think about other objects that they have seen flying and what they had that the rocket didn't. The student was able to think about an airplane and the tail that is on airplane as a possible solution to keep it from spinning. So I had them try adding a tail to their rocket to see if it would stop spinning and it did. We were then able to have a discussion about what the tail does and how it keeps the rocket from spinning.

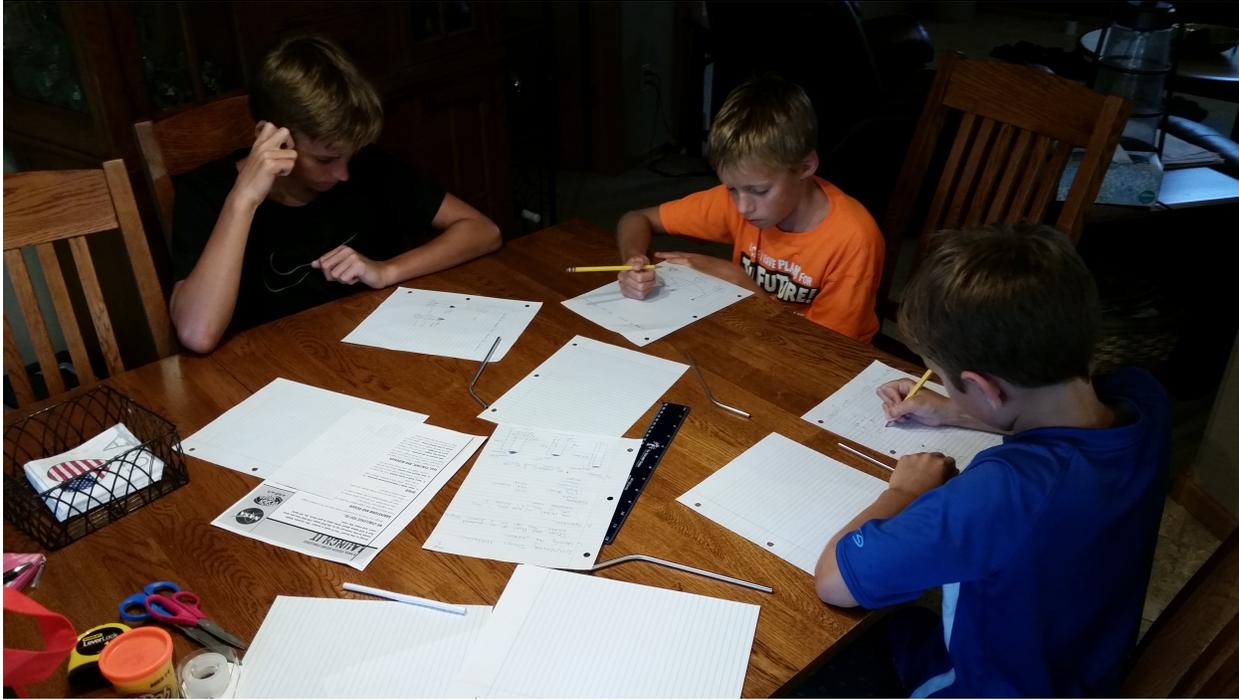
- e. I think I chose a good engineering design activity for my students. Even though I will be doing this activity with high school students instead of elementary students, I think the design process is a good one. We will just ask different questions and gather different data in the high school setting. In my classroom, we would look into projectile motion and analyze the motion of the rockets. I would do this using the Vernier Video Physics Application. This software allows students to take a video of a projectile and then create trajectory, position and velocity graphs. The students could then use this data to analyze and improve their designs. All of this can be done using the same straw rockets.
- f. To improve this activity for future students, we would need to use a thicker paper. I would also have the students work in groups instead of individually to create their design. Many times it took multiple hands just to get the rocket taped and built appropriately so working in a group would be beneficial in the build process in particular. I would also need to make this activity more complex for the high school students by looking deeper into physics concepts. I would do this as previously described using projectile motion and creating graphs. The students would then need to analyze the graphs of the motion and use that data to help guide their designs.

More Pictures from the process:

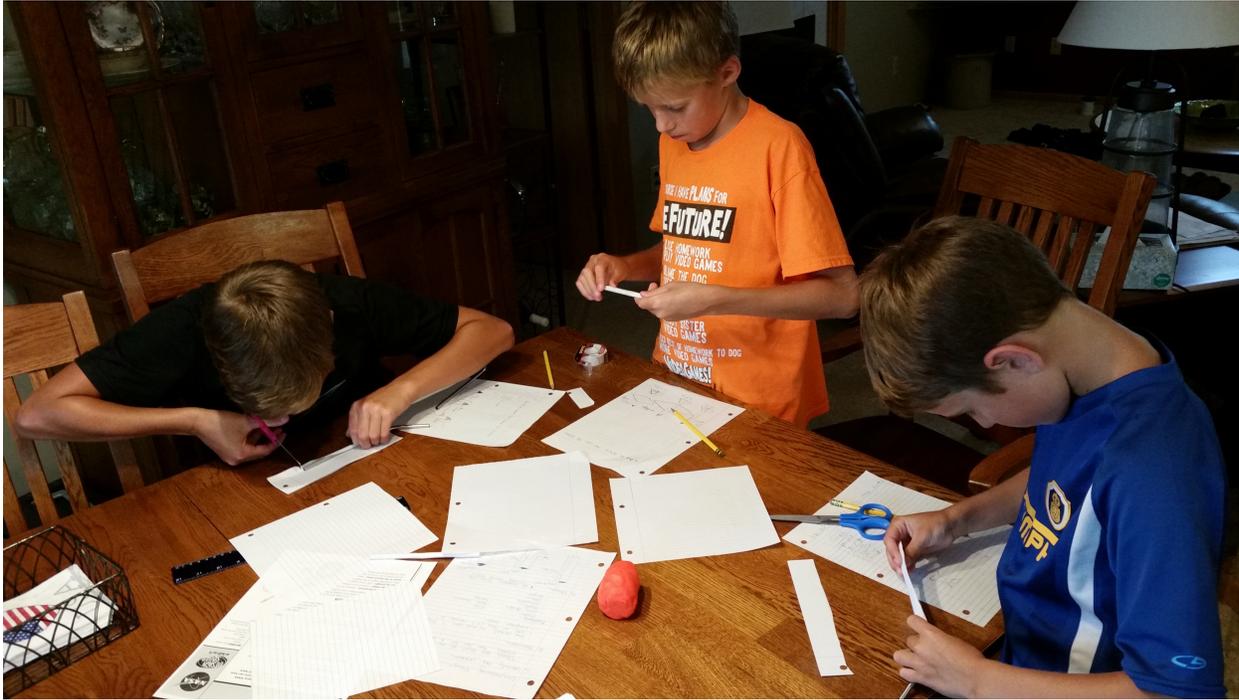
My original (simple) rocket



The design process



The build process



Test results (data)

	A	B	C
	59 in	60 in	60 in
	74 in	57 in	63 in
	45 in	61 in	66 in
	42 in	50 in	64 in
5	101 in	68 in	70 in
	28 in	74 in	48 in
	40 in	60 in	
	57 in	37 in	
10			

Launching the rockets



Resources

Common Core. (2018). *High School: Functions*. Retrieved from <http://www.corestandards.org/Math/Content/HSF/introduction/>

Kirkley, Jamie. (2003). *Principles for Teaching Problem Solving*. PLATO Learning Inc.

NGSS. (2018). *Read the Standards*. Retrieved from https://www.nextgenscience.org/search-standards?keys=&tid_4%5B%5D=All&tid_1%5B%5D=All&tid_2%5B%5D=All&tid%5B%5D=107

Vernier Software and Technology. (2018). *Video Physics*. Retrieved from <https://www.vernier.com/products/doftware/video-physics/>

WGBH Educational Foundation. (2018). *On the Moon – Challenge 1: Launch It*. Retrieved from http://pbskids.org/designsquad/parentseducators/guides/activity_guide_moon.html

WGBH Educational Foundation. (2018). *The Design Process in Action*. Retrieved from <http://pbskids.org/designsquad/parentseducators/workshop/process.html>