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Endeavor STEM Program (Adams State University)

The E in STEM: Meaningful Content for Engineering

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## Identify the problem

I chose to use the [FLUOR Paper Ball Run Challenge](#) for my engineering project. This project was completed by my 5th grade students. The main objective of the Paper Ball Run Challenge is to build a ball run that takes as long as possible for the ball to get from the entrance of the design to the exit of the run. Since the goal of the challenge is to have the slowest possible time, student's first began by identifying the problem based on that concept. Students needed to take into account concepts like kinematics, different forms of energy, simple machines, and engineering structures. This challenge also had material constraints, as well as opportunities to earn points and have points taken away. Students needed to be able to identify that this was part of the problem.

Material constraint: Construction materials included paper (maximum 30 sheets), printer or construction paper and tape (maximum one roll), clear Scotch tape or masking tape.

Scoring:

$$\textit{Final score} = (4 \times \textit{time in seconds}) - (\textit{number of sheets of paper})$$

1. What is the problem that you are trying to solve?

Where trying to find out how to make the ping pong ball go as slow as possible on a paper rollercoaster.

1. What is the problem that you are trying to solve?

We are trying to see if we can slow down a ping pong ball with just tape and paper.

1. What is the problem that you are trying to solve?

How can we make the ball go as slow as possible?

1. What is the problem that you are trying to solve?

How can we slow down the ping-pong ball in a rollercoaster made out of tape and paper?

1. What is the problem that you are trying to solve?

How can we slow the ping pong ball down  
on our paper roller coaster?

### Brainstorming

Students began their brainstorming by having access to a cardboard ramp, ping-pong ball, and paper. This was a mini challenge that I created to introduce students to the materials they would be using and allow them to explore how the ping-pong ball moved naturally and with engineered solutions to slow it down. This was the initial phase of brainstorming where students could explore a few various methods of slowing a ball down.

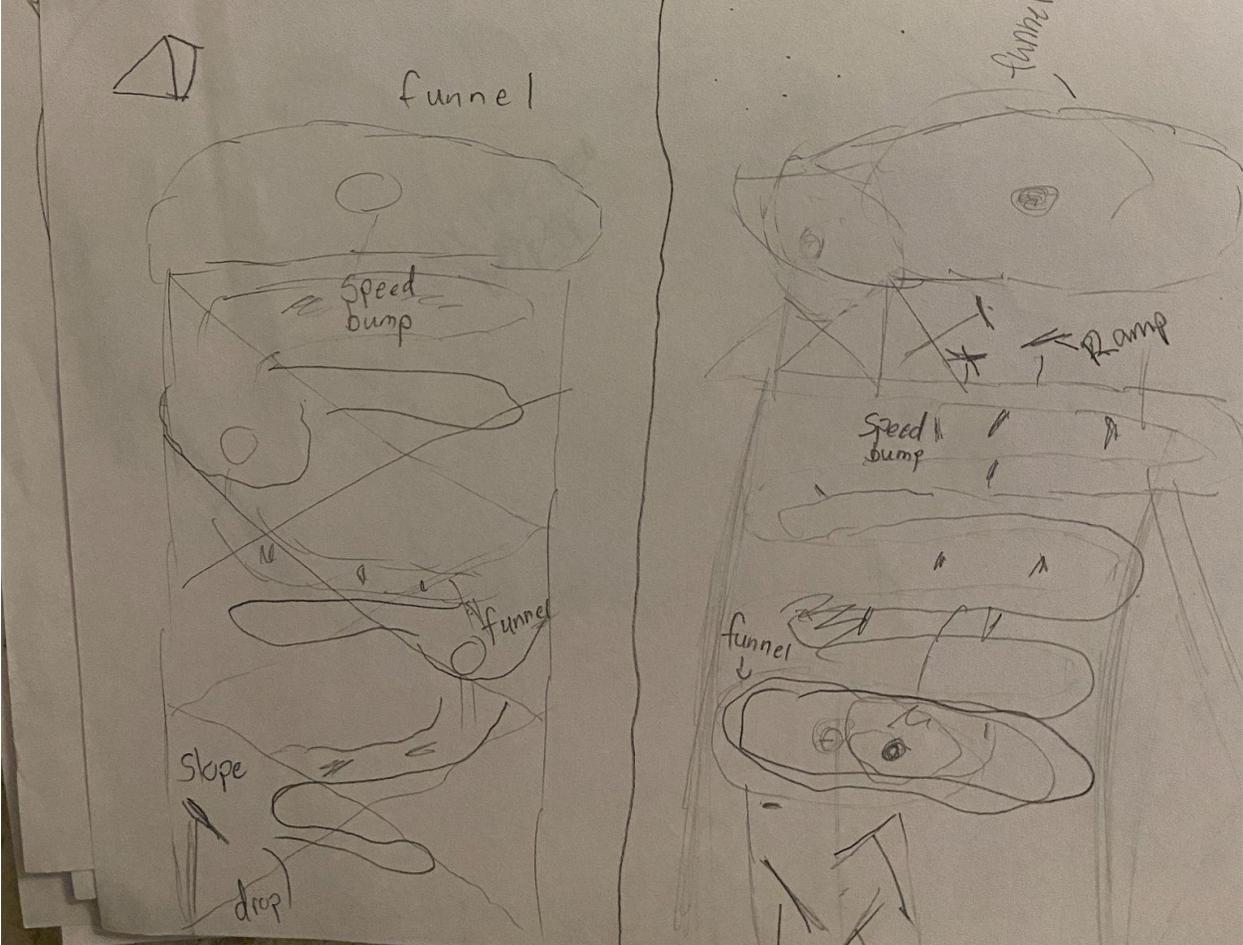


Students were also allowed to explore their materials that they would be using for their paper ball run. Teams had to decide on a type of paper (choice between printer paper and construction paper) and a type of tape (choice between masking tape and Scotch tape). During this brainstorming phase, students were encouraged to try all 4 combinations of materials so that they could make an informed decision for their final project. Once their decision was made for their final project, they could not switch materials. This was a crucial step in their brainstorming phase because their choice could determine the success of their final design.

### **Design**

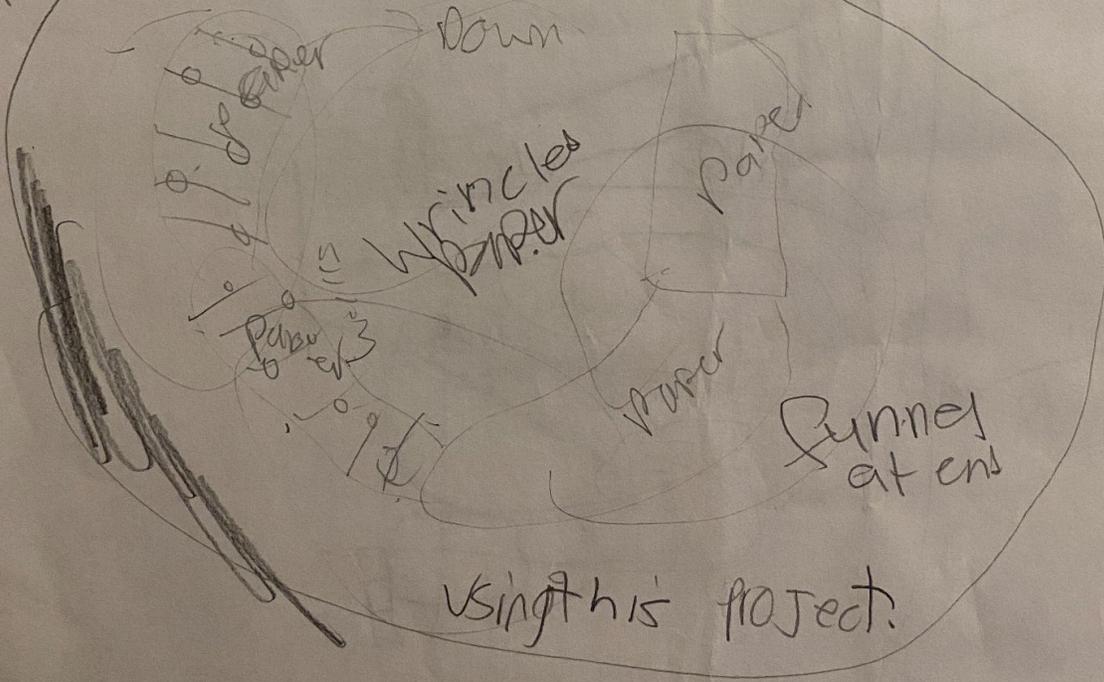
Students completed a design sheet on paper. On their design sheet, students were asked to draw two ideas for their paper roller coaster. Student designs had to include labels of specific solutions that they were using in order to slow their ping-pong ball down (i.e. speed bumps, slopes, funnels). Students were then asked to pick their final design and make a materials list.

2. **Design.** Use this page to draw design ideas for two different paper ball runs. Use the back of the page if you need more space.



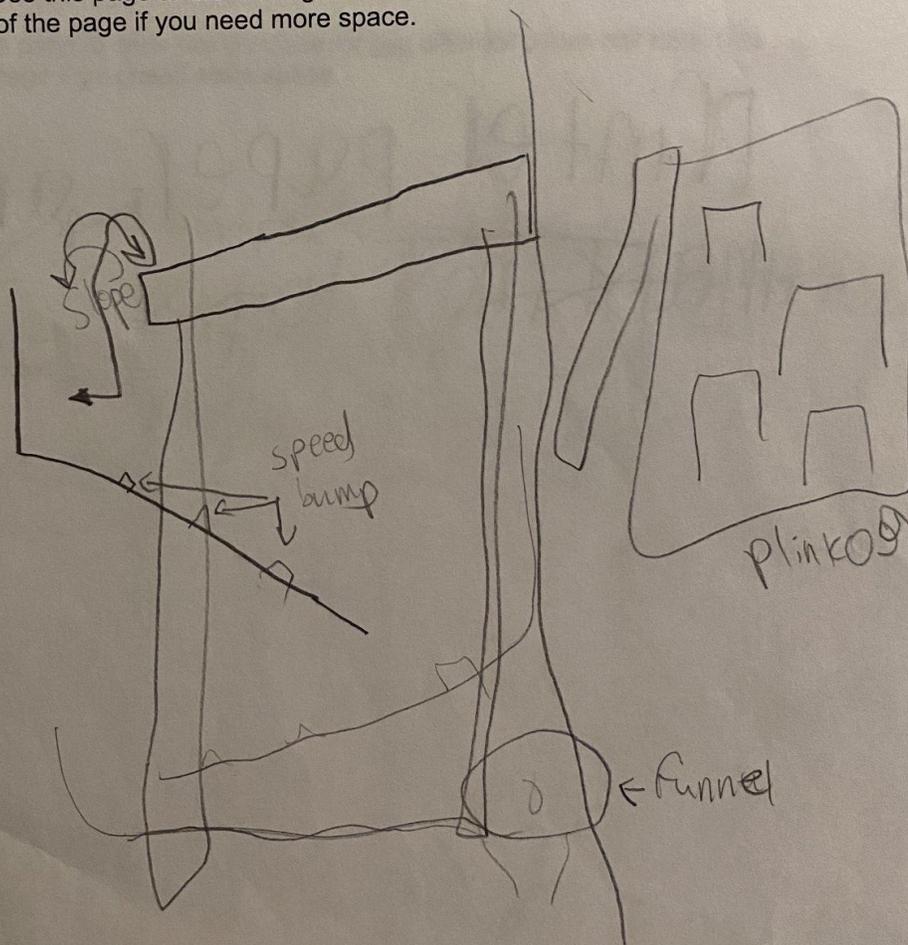
2. **Design.** Use this page to draw design ideas for two different paper ball runs. Use the back of the page if you need more space.

30 pc of paper

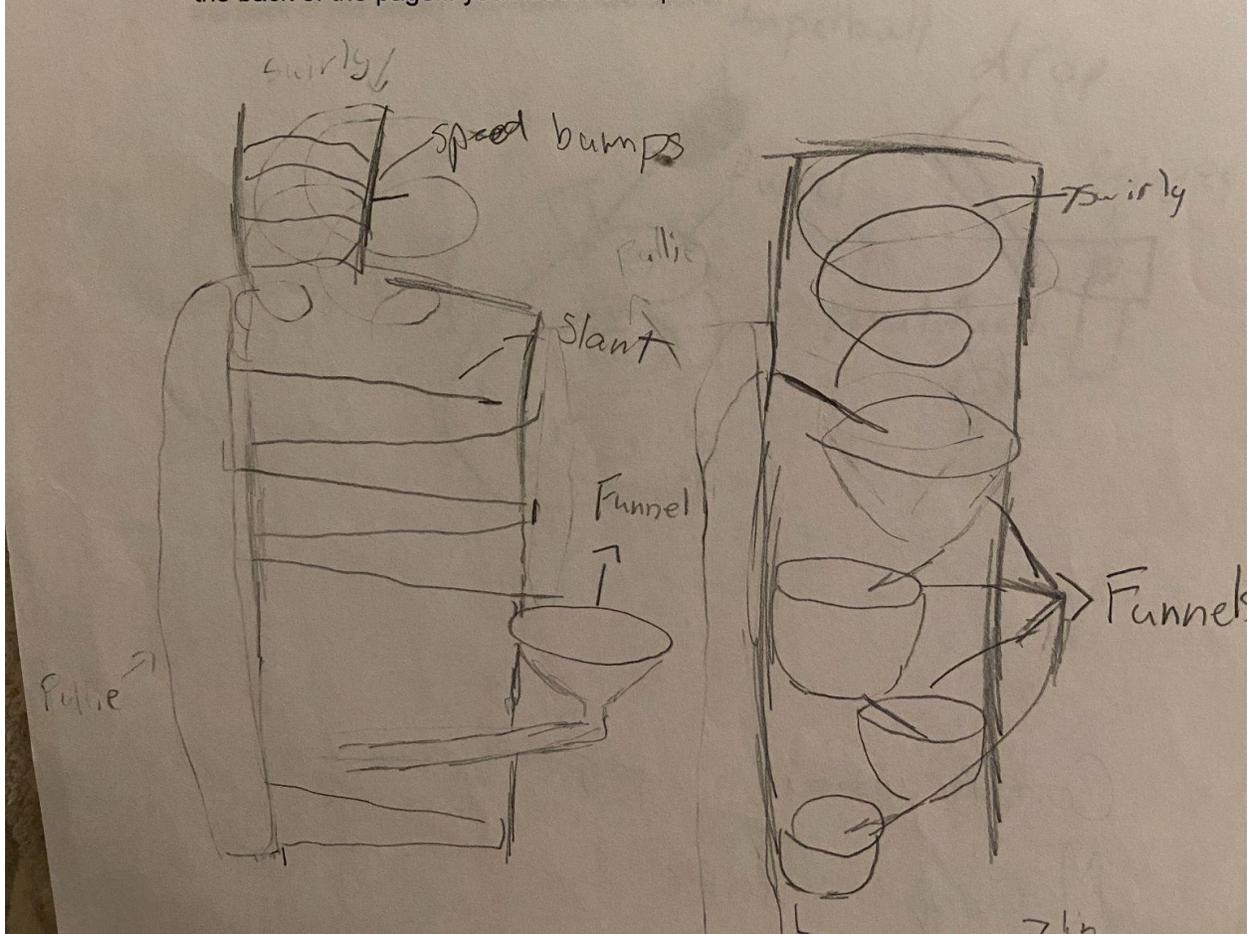


Other design

2. **Design.** Use this page to draw design ideas for two different paper ball runs. Use the back of the page if you need more space.



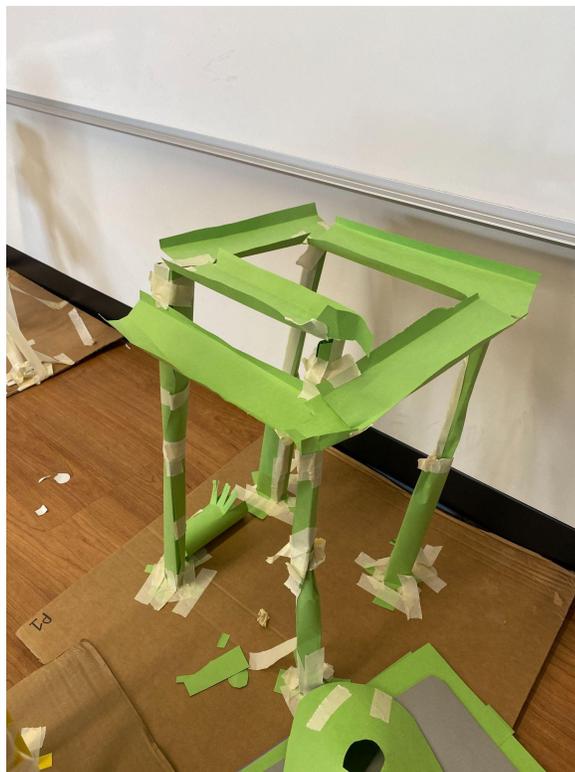
2. **Design.** Use this page to draw design ideas for two different paper ball runs. Use the back of the page if you need more space.



### Build

After deciding on a design and their materials, students began building their paper ball runs.

Students had about 6 class periods (45 minutes) to work on their final projects.



**Test and Evaluate**

Testing and evaluating was done throughout the building challenge. Students were encouraged to test at every step of their design phase and at the end of each class. At the end of each class, students would do a final test run and record that time for the day. These times were recorded on one single testing sheet so they could continuously try to beat their slowest score. Some teams' times started off strong but then slowly decreased, while others increased their time consistently throughout the challenge.



Test. At the end of each class, record how long it took for your ping-pong ball to go through your paper roller coaster.

	Time (in seconds)
Class 1	3.07
Class 2	3.07
Class 3	<del>6.29</del>
Class 4	2.27
Class 5	4.52
Class 6	6.19

Test. At the end of each class, record how long it took for your ping-pong ball to go through your paper roller coaster.

	Time (in seconds)
Class 1	2.74
Class 2	4.52
Class 3	9.33
Class 4	9.73
Class 5	11.62
Class 6	11.82

## Redesign

Throughout the challenge, students were constantly working through multiple iterations. Since the goal of the challenge was to have the slowest possible time, students were encouraged to continue adding new ideas to their creation to improve their scores.



**Share the solution**

Sharing solutions took place throughout the engineering project, as well as during the final testing day. Each class, a designated 5 minute period was given to students to do a “museum walk” around the room to look at other teams’ designs. The purpose of these museum walks was to encourage students to look for creative ideas that other team’s were using and gain inspiration and/or guidance from others. On the final testing day, students watched each design be tested for their final score and were able to point out the features within each ball run that made it successful.

Student reflections:

1. Did your paper roller coaster look like your original design? What parts did you remove?

No it did not. we removed 3 Funnels

2. During testing, did the ball get stuck at all? If so, why?

It did. It got stuck cause of the paper sticking up.

3. Did any parts of your paper roller coaster break or not work like you wanted them to? If so, why?

The supports broke alot.

I am

proud

4. What are you most proud of about your paper roller coaster?

of The end of it.

1. Did your paper roller coaster look like your original design? What parts did you remove?

NO. We came back one day and it was destroyed! So we restarted and did not use our original design.

2. During testing, did the ball get stuck at all? If so, why?

The ball got stuck plenty of times throughout the design process. Usually it was because the paper was going in the wrong direction or the speed bump was too long.

3. Did any parts of your paper roller coaster break or not work like you wanted them to? If so, why?

The funnel didn't work as we wanted it to. It was because of the shape and not having a big enough hole.

4. What are you most proud of about your paper roller coaster?

I am proud that it worked and that it didn't fail.

1. Did your paper roller coaster look like your original design? What parts did you remove?

No. Our plan had a funnel in the top, but ours turned out to be in the middle. The track was also supposed to go in a circle, but instead it went all over the place.

2. During testing, did the ball get stuck at all? If so, why?

Yes. The ball mostly got stuck at a turning point, so our solution was to take off the speedbumps, and lower the support.

3. Did any parts of your paper roller coaster break or not work like you wanted them to? If so, why?

The funnel didn't exactly work out as we planned because we had to use a lot of tape for it not to get stuck, so it got really heavy.

4. What are you most proud of about your paper roller coaster?

Although there were a lot of difficulties with the funnel, that was my favorite part. It turned out really slow.

1. Did your paper roller coaster look like your original design? What parts did you remove?

No it did not look like our original design.  
We took out the pulley and the spinning  
kind of turning tracks.

2. During testing, did the ball get stuck at all? If so, why?

Yes it did get stuck because sometimes  
our ramp wasn't slanted enough and other  
times it was the tapes

3. Did any parts of your paper roller coaster break or not work like you wanted them to? If so, why?

All of our rollercoaster broke because the  
supports were not as stable as  
they seemed.

4. What are you most proud of about your paper roller coaster?

I am proud that me and my partner  
did not stop working even <sup>though</sup> everything  
fell apart.

1. Did your paper roller coaster look like your original design? What parts did you remove?

In our original design I had a spiral plinko board and a pulley system. Every thing we wanted to add did not make it into our roller coaster. So we started from scratch.

2. During testing, did the ball get stuck at all? If so, why?

yes, multiple times, because our funnel was too low and our turnle was too small. But I learned that we just needed to keep on trying.

3. Did any parts of your paper roller coaster break or not work like you wanted them to? If so, why?

yes! Trial + Error. lots of times the tape would not stick to the paper because of the humidity. Or the base would keep falling over.

4. What are you most proud of about your paper roller coaster?

I am most proud of the teamwork and our G.R.I.T. We did not stop trying no matter what happened and in the end we got something standing.

1. Did your paper roller coaster look like your original design? What parts did you remove?

It did not look like our design but we still had features from our original sketch built into our rollercoaster.

2. During testing, did the ball get stuck at all? If so, why?

The ball got stuck two times during the actual test because of a divot in one of the rollers on the bottom track.

3. Did any parts of your paper roller coaster break or not work like you wanted them to? If so, why?

Well at the end of the coaster on the last ramp instead of it being a ramp it was basically a stopper.

4. What are you most proud of about your paper roller coaster?

I'm most proud of the funnel in the end because it was before the one that had the slowest time out of all of our features.

## Reflection

This project was extremely engaging for students. Each time my 5th graders came to class, they were excited to come in, get right to work, and build. Looking at their final reflections, I was so pleased that they were able to recognize that they worked with grit and a growth mindset despite the many challenges they faced. I turned this challenge into a grade-wide

competition, so my students were highly motivated by the thought of bragging rights. Most of all, my students learned a lot. Students went into the project thinking it was going to be simple but quickly learned that it was a difficult challenge. Working with limited resources (only 30 sheets of paper) and knowing that the paper they use affects their final score (points taken away for each sheet of paper used), students had to be thoughtful and creative at each step. This was a fantastic way to teach my students about the real-world engineers who deal with criteria and constraints on a daily basis.

While this was an exciting, engaging project for my students, there were a few things that were challenging throughout the project. One of the biggest challenges to this project were environmental factors within my classroom. My classroom has been dealing with humidity problems and of course, humidity and paper do not mix. Many of my students' designs were destroyed each night because of high humidity levels. This definitely caused frustration levels to rise. I also teach grades 3 other grade levels, so my room was always being used by another grade besides 5th. Occasionally, materials would fall onto the paper ball runs or someone would spill water near a design. My students began using these environmental factors as an excuse for a "failed" testing attempt, even if that wasn't entirely true or the root cause of the issue. Another challenge was the length of this project. The project definitely needed to be long enough for students to get a working paper roller coaster up, but some teams found it difficult to work with one partner for so long. In the final building week, two of my students were upset, frustrated, and angry that their designs were "failing". Unkind words were used, paper roller coasters were intentionally destroyed, and I saw many of these kids just choose to give up. This behavior doesn't happen often in my classroom (where students are visibly upset and angry), so it was a difficult experience for me as a STEM teacher.

This engineering challenge focuses on these aspects of NGSS Three Dimensional Learning: 1. Science & Engineering Practices (Constructing Explanations and Designing Solutions. Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.) 2. Disciplinary Core Ideas (ETS1.B: Developing Possible Solutions. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.) 3. Crosscutting Concepts (Scale, Proportion, and Quantity. Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.)

The engineering design process was extremely helpful during this project. Not only was it an organized way to keep my students on track, but it was a great visual for them to have as well. When I have previously taught the engineering design process, it was hard to explain to my students that it is completely normal to jump back and forth between steps or stay in a step for extended periods of time. This project allowed students to really understand that trial and error are normal in engineering. I would not change the base of my engineering design process, but I would add additional arrows to my process to help students better understand that the engineering design process is not linear and does not even have to be cyclical. It is okay to stay at a certain stage for a long period of time or even go back to earlier stages.

When thinking of doing this project with future students, I would consider shortening the project time. Most of the frustration came from having to work on the project for multiple classes/weeks. Given the environmental factors and frustration from materials and groupmates, the timeline could potentially be shortened to reduce some of these issues. I would also consider only allotting part of class for build time. During this project, I allowed my students to have 6 (almost) full classes of building time. Perhaps breaking up that time with different activities or

being able to work with different partners on other projects would reduce some of these issues as well.

[Additional videos of the paper roller coasters linked here.](#) Enjoy!