Major Product: Engineering Design Challenge

Phase 2 – Implementation

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Endeavor STEM Teaching Certificate Project

Engineering Design Process

The EiE (Engineering is Elementary) design process was implemented for this engineering design challenge. This process includes the following five steps: 1) Ask, 2) Imagine, 3) Plan, 4) Create, and 5) Improve (Engineering Design Process, 2019). This process was chosen because it is a simple and easy to understand process appropriate for elementary-age students.

Timeline and Activities

The engineering design challenge, Touchdown, was implemented with third grade students. This is a challenge from the NASA "On the Moon Educator Guide." This challenge involves designing and building a shock-absorbing system that will protect two marshmallow "astronauts" when they land (On the Moon Educator Guide, 2009). The "Big" concept is the need for a fast-moving spacecraft to land gently on the moon. Students will use the engineering design process to brainstorm and design a spacecraft, build it, then test, evaluate, and redesign. Topics such as potential and kinetic energy, acceleration due to gravity, air resistance, and measurement are all critical for this activity.

This engineering design challenge was implemented over several days. Prior to the actual engineering challenge, the students watched the video, "160 Beats Per Minute: The Final, Frantic Moments Before the Historic Moon Landing" (NBC News, 2018). This video shows footage from Apollo 11, when astronauts successfully landed on the moon. The final moments that lead to this famous historical event were shown in this video. This "phenomenon" was used to hook the students in and get them excited about learning. Other activities included reading books about the moon and its surface and pre-challenge activities related to space and the moon to provide background information.

The engineering design process steps were then reviewed: 1) Ask, 2) Imagine, 3) Plan, 4) Create, and 5) Improve (Engineering Design Process, 2019). Students were also reminded of the following STEM rules: 1) Use the materials correctly, 2) Always be working, and 3) Don't say, "I'm done." For rule 1, students were reminded to be careful with materials and to not eat any food items. For rule 2, students were reminded that they should use their time wisely and not waste time. Rule 3 is important because students should continue to work to make improvements with their project. I reminded students that there are always changes and improvements that can be made. I discussed that this is what engineers do when they are working on important projects.

Students then completed the engineering design that is found in the engineering design notebook that follows. They began by spending a good amount of time planning. They worked on the "Touchdown Planning Sheet" (Appendix A). As part of this phase of the project, I explained to the students that their challenge was to design and build a shock-absorbing system that will protect two "astronauts" when they land. We discussed what it means to be shock-absorbing and discussed ways that this might happen. I showed students their materials. The following materials to make each lander were organized in a Ziplock bag for each group: 1 piece of cardboard, 1 small plastic cup, 3 index cards, 2 regular marshmallows, 10 miniature marshmallows, 3 rubber bands, 8 plastic straws, scissors, and tape.

Students were then given time to brainstorm and design. They could use the space on the bottom or back of the paper or get additional paper, if necessary. Even though it was tempting, students were not permitted to use any of the materials at this point or to start building during this time.

Students then worked on the actual STEM challenge. They spent time creating, building, solving problems, improving upon their designs, and making changes as needed. (Detailed steps and pictures of this part are included in the Engineering Design Notebook that follows).

Following the engineering design challenge, students completed a self-reflection (Appendix B). They reflected on how they think they did, how their team did, what wet well, and what they could improve on for next time. Students also did a follow-up writing activity about traveling to the moon (Appendix C). They described what it would be like on the moon and what they would do when they arrived on the moon. Students will also have the opportunity to research jobs at NASA and to do a follow-up "Touchdown" activity in which students suggest different materials to use.

Engineering Notebook

Touchdown Engineering Notebook

1. Identify the Problem

The challenge was for students to design and build a shock-absorbing system that would protect two "astronauts" when they land. Students were introduced to this through a lesson on the Smartboard. There was a class discussion about the engineering design process that they would use. This was reviewed with the students. They learned that their goal was to build a shock-absorbing system out of paper, straws, and mini-marshmallows and then attach their shock absorber to a carboard platform. Students watched a video showing the Apollo 11 spacecraft landing on the moon. (https://www.youtube.com/watch?v=zplHIWNfR7Q)

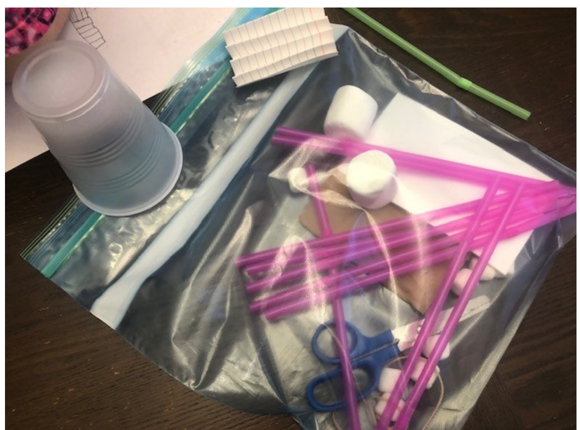
Students shared what they noticed.

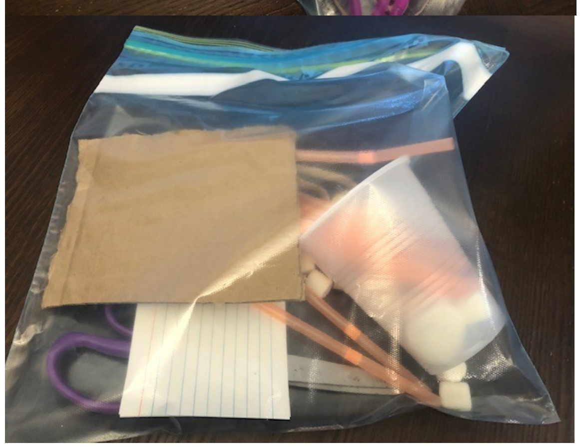
There was then a discussion regarding how spacecrafts would land. I demonstrated jumping off a chair and how I landed. I asked students what they noticed and they shared ideas such as how I bent my knees when I landed. I told students to think about this when they are creating their landers.

Students were then shown the following materials that they would use.

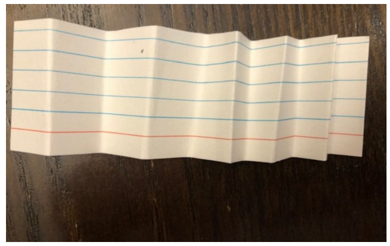
Materials: (per lander)

- 1 piece of cardboard
- 1 small plastic cup
- 3 index cards
- 2 regular marshmallows
- 10 miniature marshmallows
- 3 rubber bands
- 8 plastic straws
- Scissors
- Tape





These were organized in a large Ziploc bag for each group to allow for easy distribution of materials. I shared my sample bag to show each of the materials. I explained to the students that the two regular marshmallows will go in the cup and represent the “astronauts.” I also gave important instructions and reminders such as not to each the marshmallows, and how to fold the index card accordion style to make a spring. I demonstrated this.

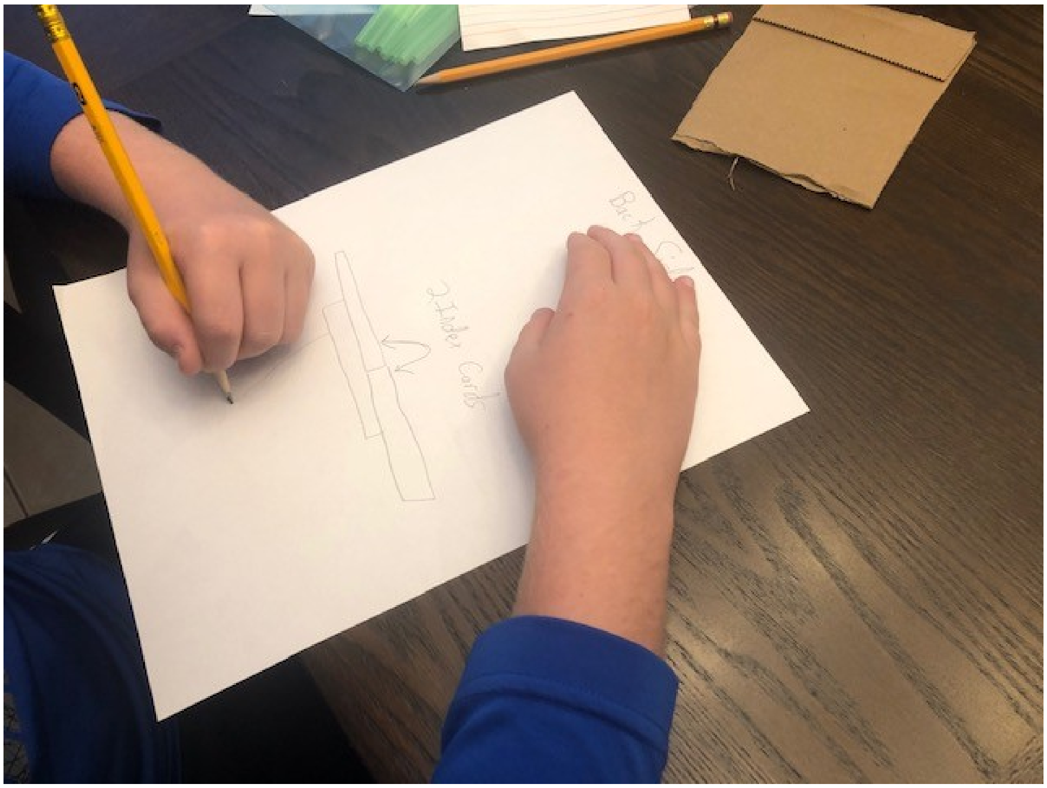


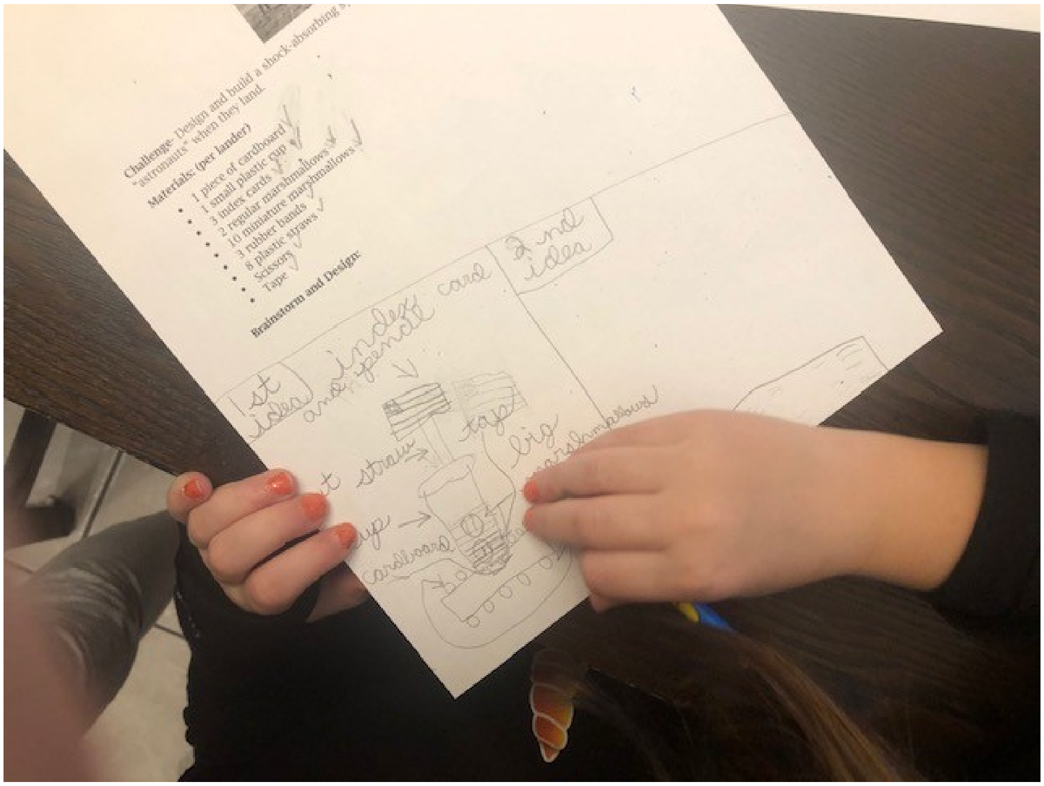
2. Brainstorming

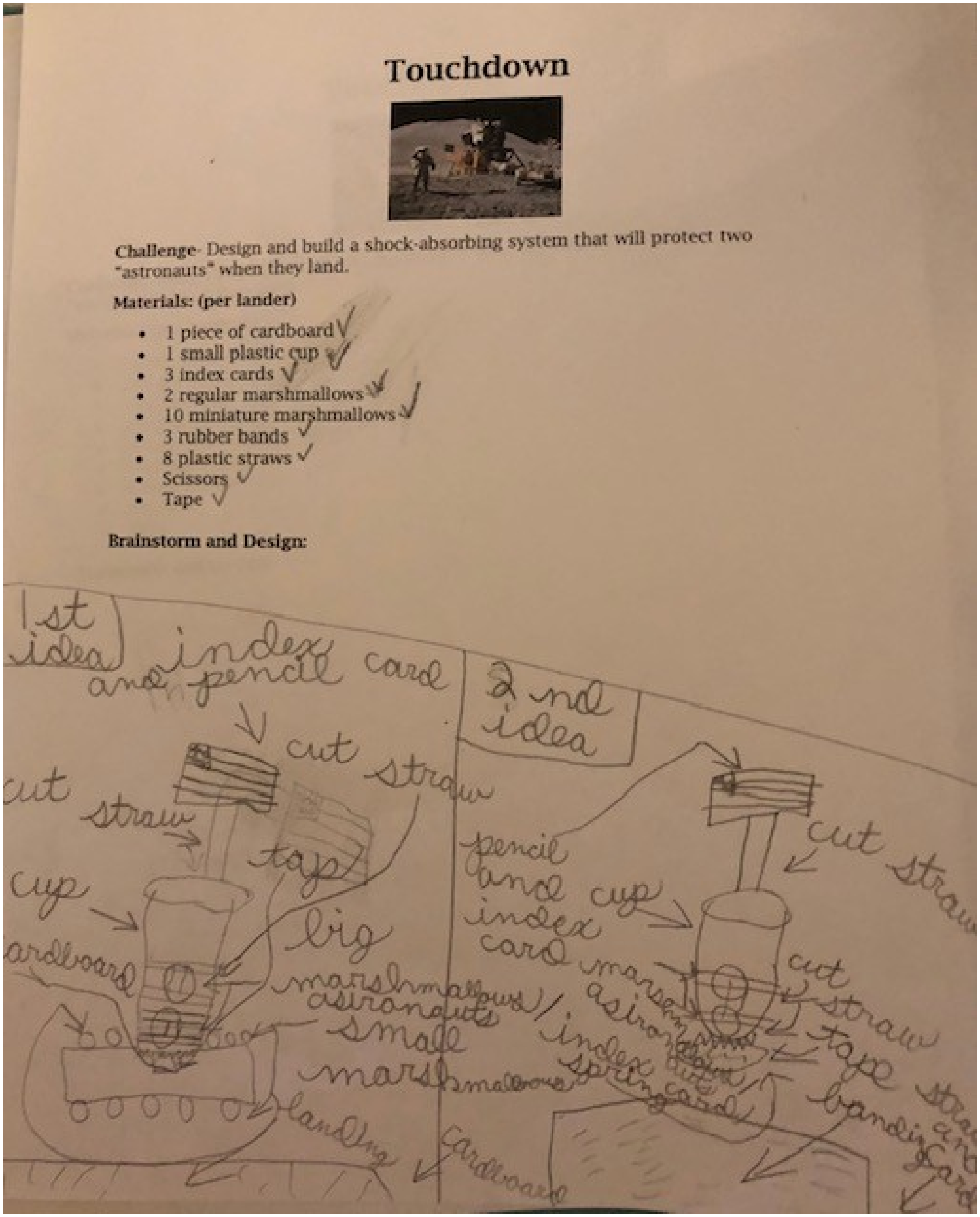
We discussed materials that could be used to create shock absorbers. I had the students think about what kind of shock absorber they could make from the materials that can help soften a landing. We talked about springs and cushions and how these work. The students brainstormed how the materials could be used such as the mini marshmallows serving as soft footpads, the cards folded into springs, and the rubber bands flexing to hold things together. I also discussed the constraints such as keeping the lander upright so it does not tip over as it falls through the air. Several students asked if they could cover up the cup with an index card to keep the astronauts safe inside and I said no. They needed to design a spacecraft that would land softly enough that the marshmallows would stay safe inside on their own. Some students asked if they could use a pencil to draw things on their lander and I said that would be ok.

Students first brainstormed independently by jotting down notes and drawing sketches. See below for pictures of this step. Students were very engaged and focused. They worked quietly during this part of the project. A few students came up with two ideas that they would share with their team. Some students were frustrated that they could not use their materials yet. I wanted them to really spend a good deal of time on the planning process and not rush to build.

Students seemed very excited for this challenge. One student said, “Oohh…I got an idea!!” Another student commented, “This is fun!” I could see the enthusiasm and motivation that the student had as they brainstormed for this challenge.




Challenge- Design and build a shock-absorbing
"astronauts" when they land.
Materials: (per lander)
1 piece of cardboard
1 small plastic cup
3 index cards
2 regular marshmallows
10 miniature marshmallows
3 rubber bands
8 plastic straws
Scissors
Tape
Brainstorm and Design:
1st idea
2nd idea
index card
tape
big
cardboard



Touchdown

Challenge- Design and build a shock-absorbing system that will protect two "astronauts" when they land.

Materials: (per lander)

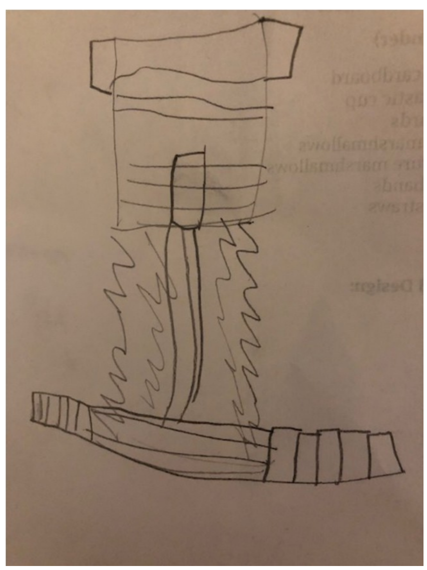
- 1 piece of cardboard
- 1 small plastic cup
- 3 index cards
- 2 regular marshmallows
- 10 miniature marshmallows
- 3 rubber bands
- 8 plastic straws
- Scissors
- Tape

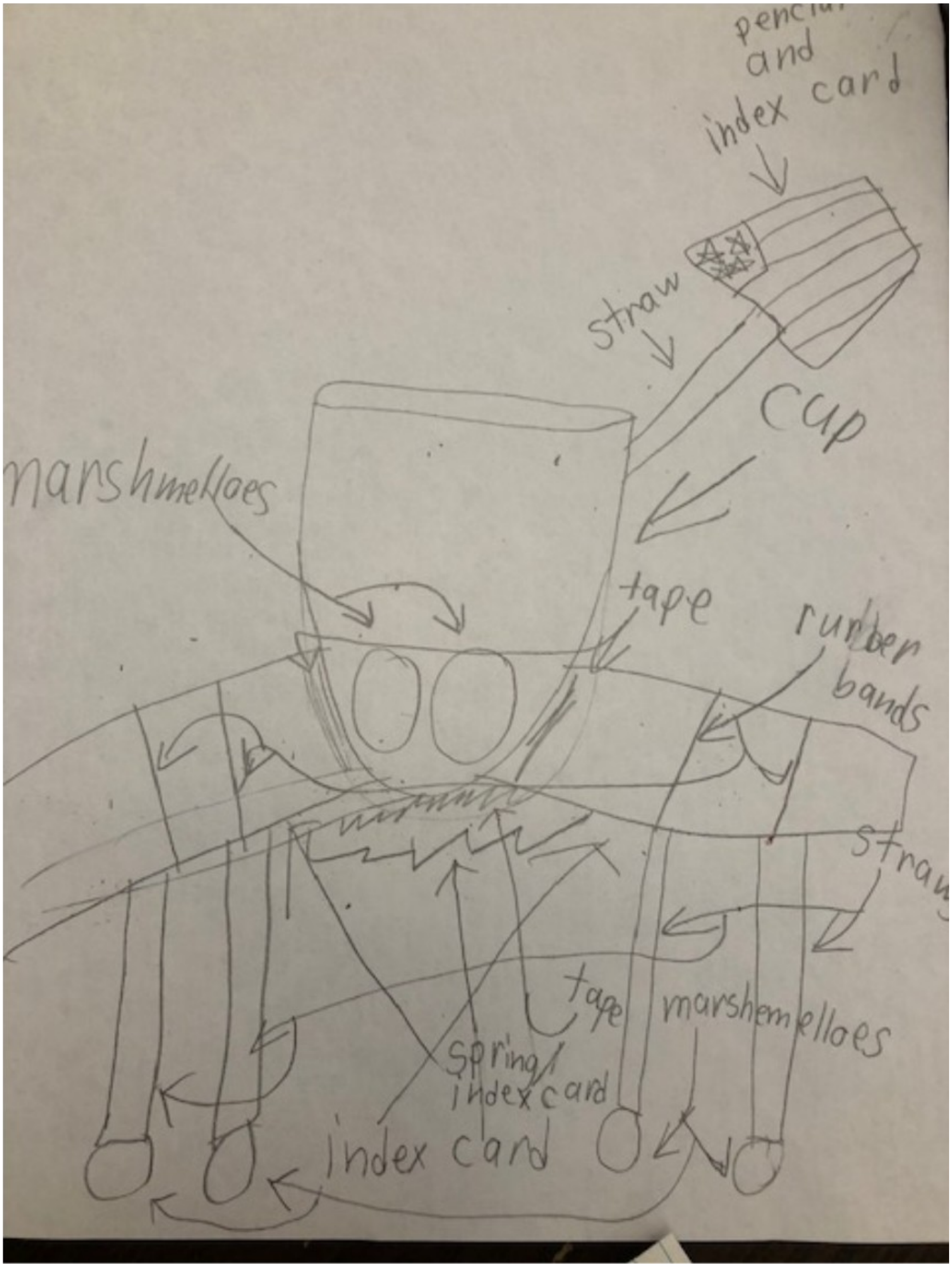
Brainstorm and Design:

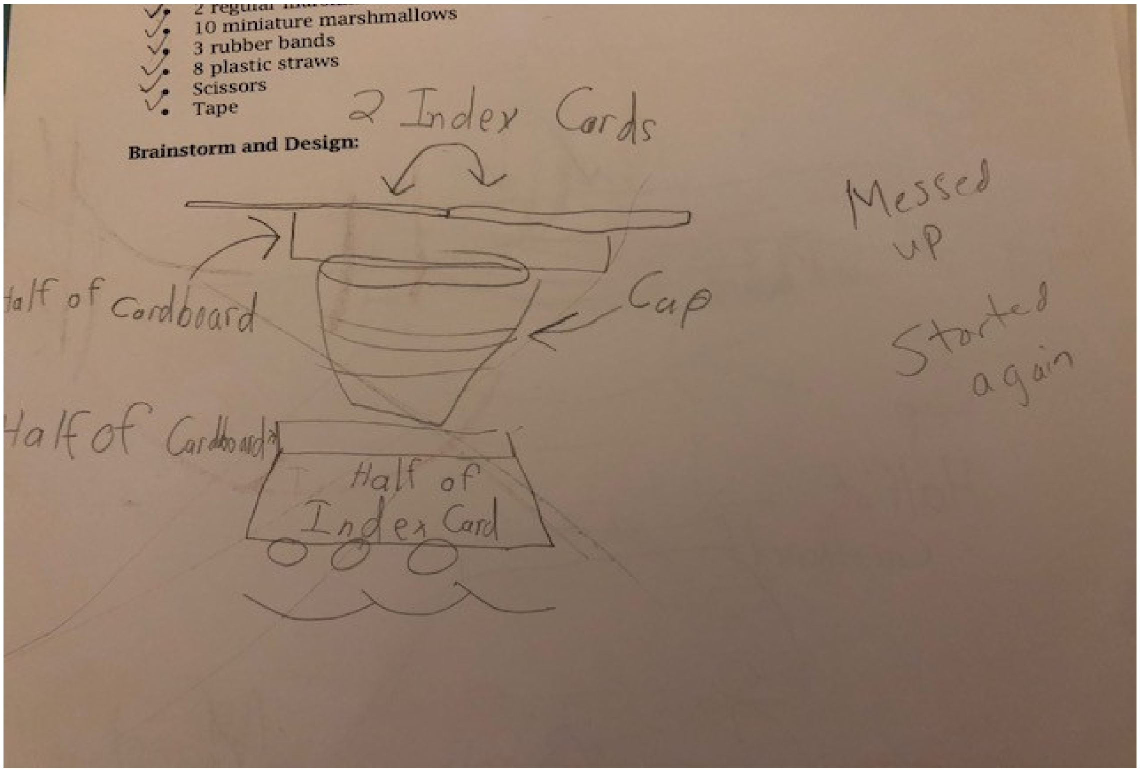
3. Design

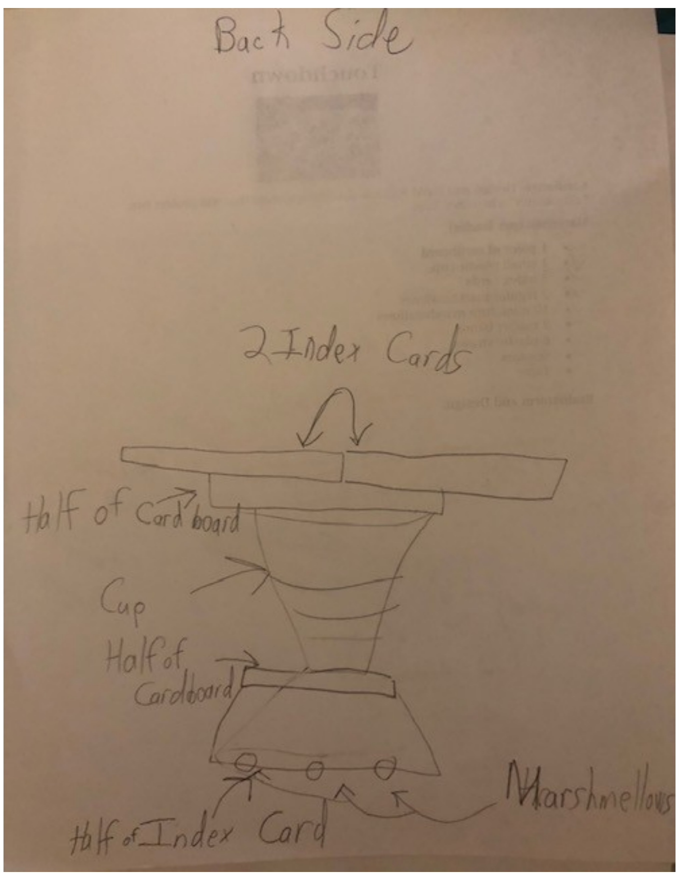
Students were then put in groups of three to share their ideas with their team. They were reminded of the rules for working on a team such as not interrupting each other, allowing all to share their thoughts, and staying focused and working together. The students were eager to share their ideas and were every positive towards their group members. They then took the “best ideas” from the group members to create the final plans for their challenge.

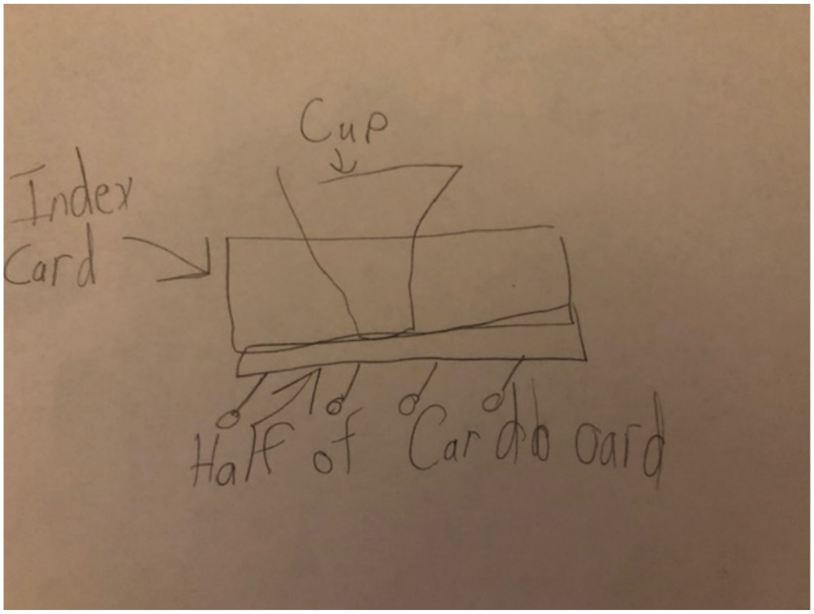
It was interesting how some teams had very detailed pictures with labels, while others took more notes and wrote about their plan. There were a lot of great ideas that were shared and discussed. Some students did need to change their ideas. For example, one group was frustrated because their design involved putting the index card on top of the cup, which they weren’t supposed to do. They had to come up with a new plan.




and
index card
straw
cup
marshmelloes
tape
rubber
bands
tape
marshemelloes
spring/
index card
index card


2 regular marshmallows
10 miniature marshmallows
3 rubber bands
8 plastic straws
Scissors
Tape
Brainstorm and Design:
2 Index Cards
Half of Cardboard
Cup
Half of Cardboard
Half of Index Card
Messed up
Started again


Back Side
2 Index Cards
Half of Cardboard
Cup
Half of Cardboard
Marshmellows
Half of Index Card

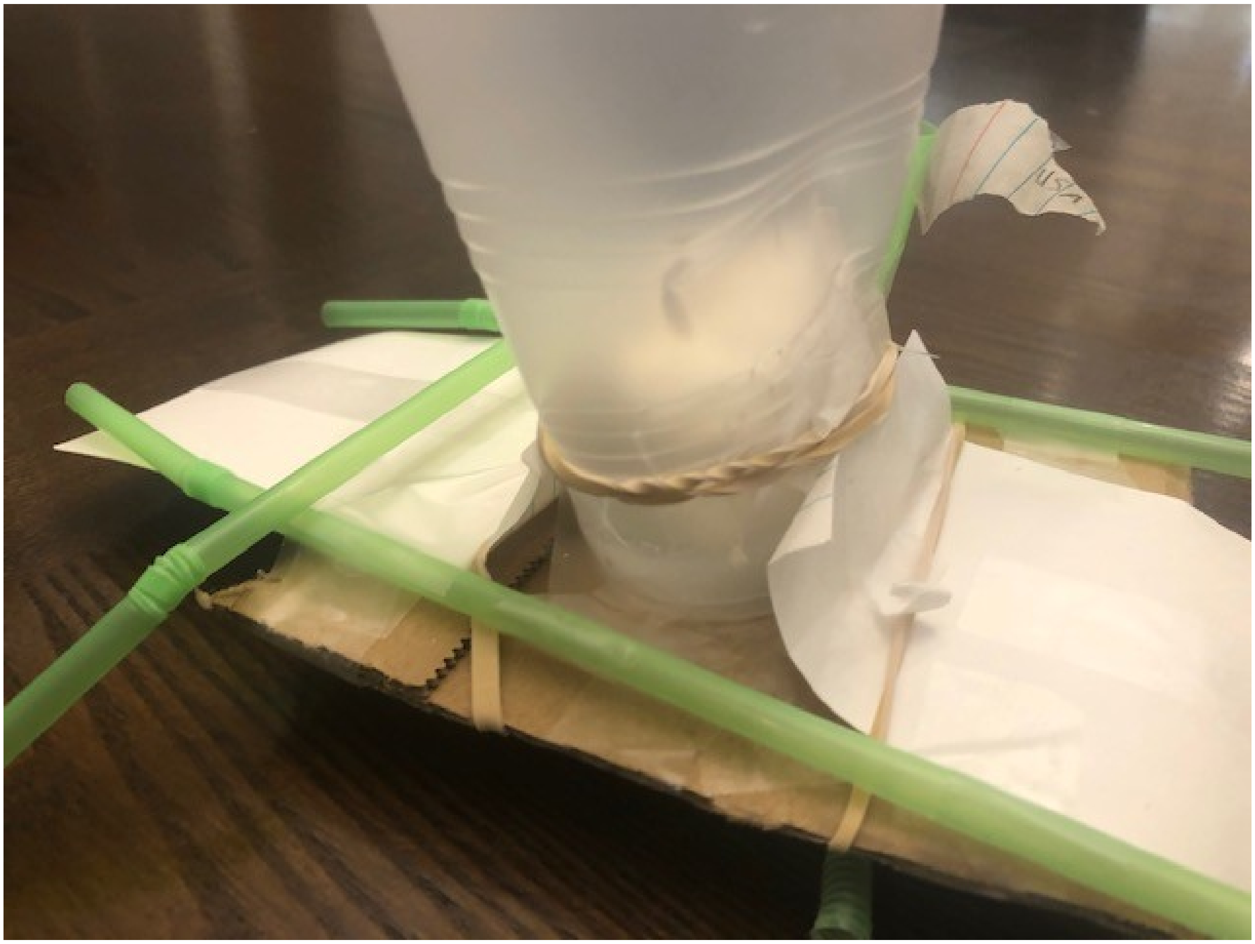


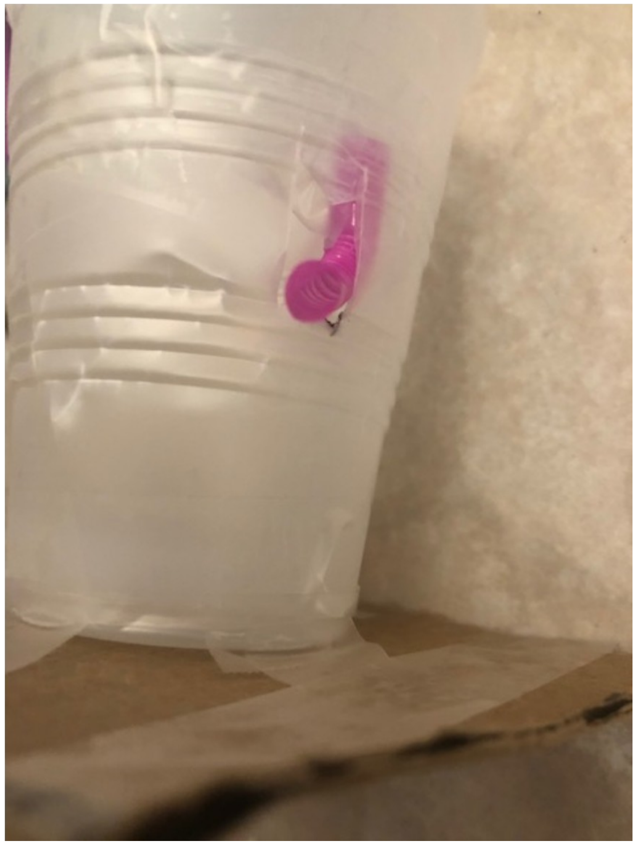
4. Build

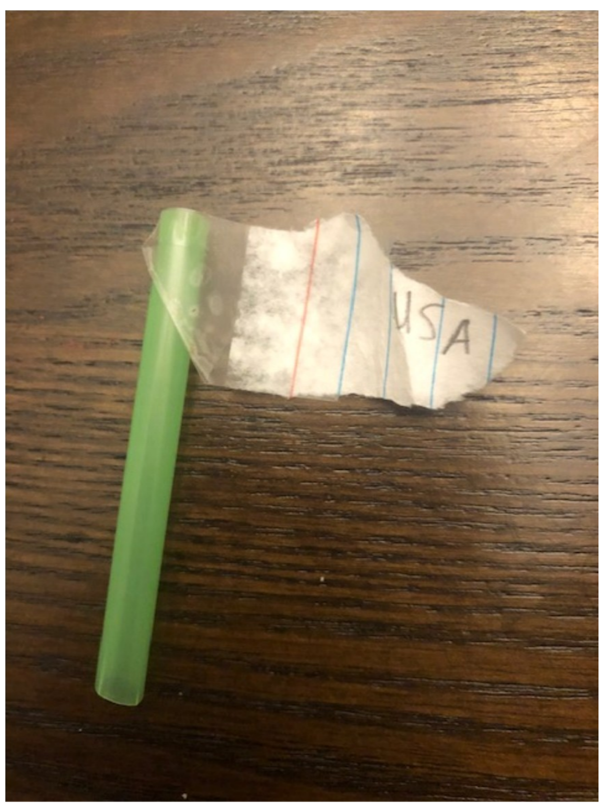
The students were very excited to build! It was now time for them to put their spacecraft together. I reminded them to attach the shock absorbers to the cardboard platform and to add a cabin for the astronauts. The two astronauts (the large marshmallows) needed to stay in it. I let students know that they could move around the room, stand up, and stretch out while they worked. It was fascinating to watch all the teams work together. They were really engrossed in the activity and all students were contributing to the design of the lander. Most groups were actively engaged and behavior was great. The motivation for this project kept students on-task and following the rules.

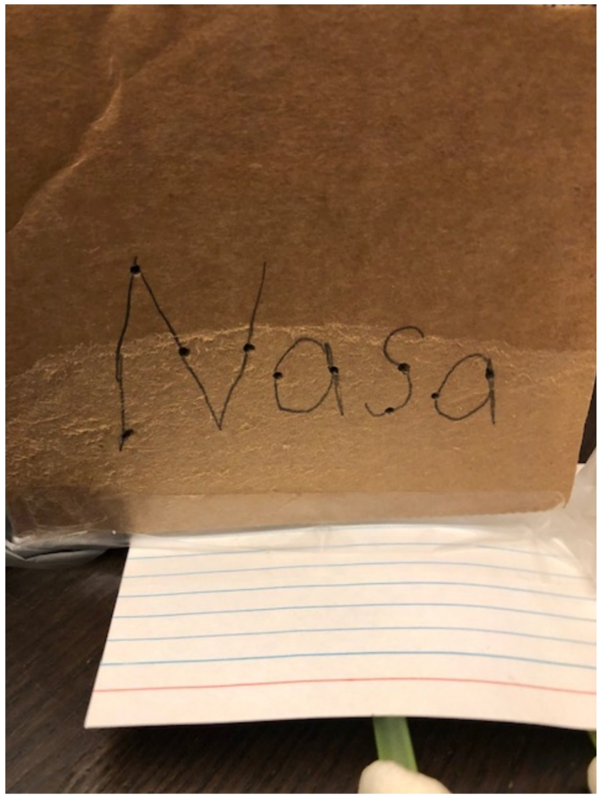
I was impressed by the “out of the box” ideas that I saw. One student cut a hole in the side of the cup and stuck a piece of straw out of it. She said it was like a telescope to look out the window. I thought this was very creative. Other students wrote NASA on their spacecrafts and some students even incorporated American flags based on the video showing the astronauts putting the American flag on the moon when they landed.

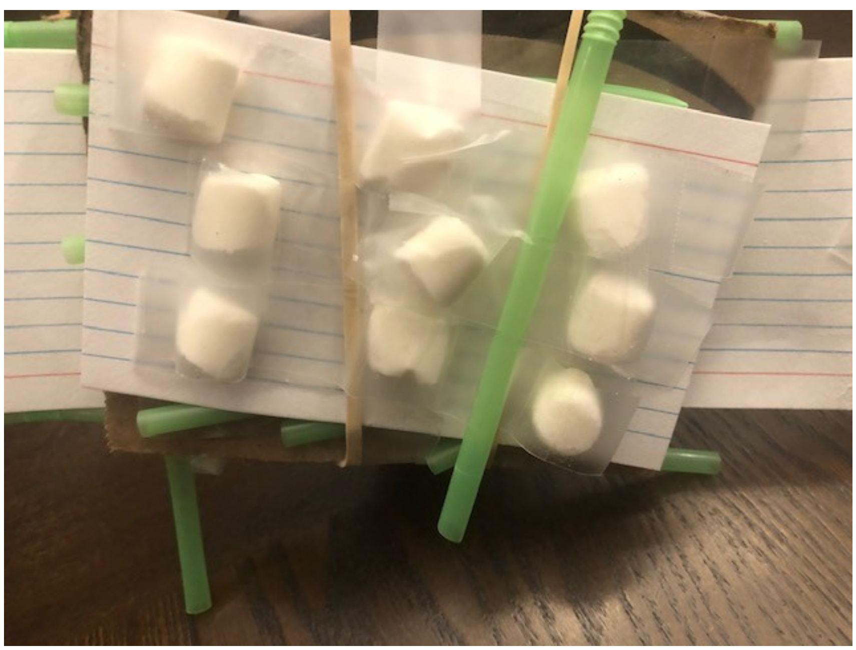
I also loved how supportive the students were towards each other. Students were complimenting each other. I heard the following, “Yours is looking good.” “Thanks!” “Yours looks great too!” “That looks cool!” “I like your idea!” Wow..that is awesome!” These positive comments made me very happy to hear.

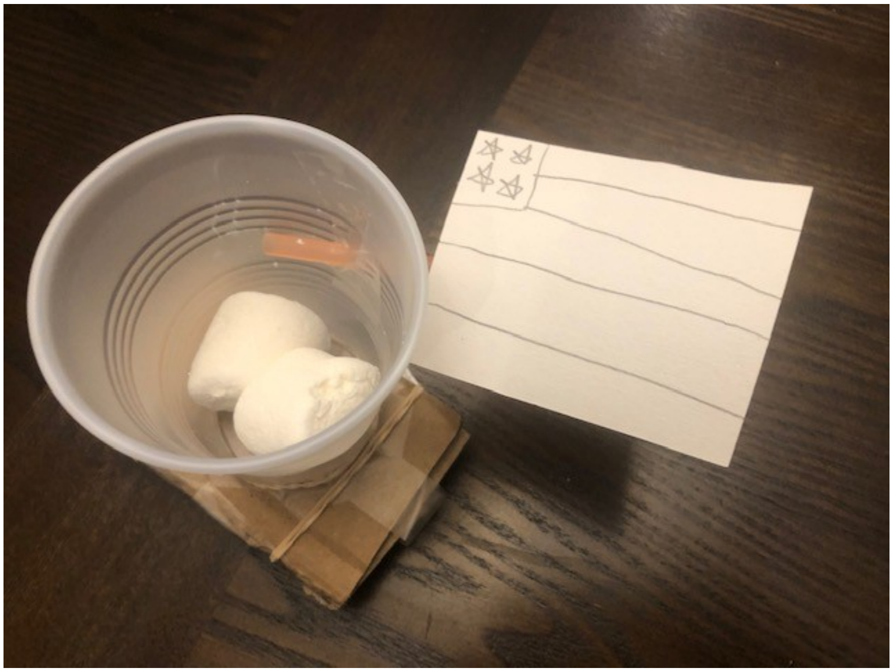


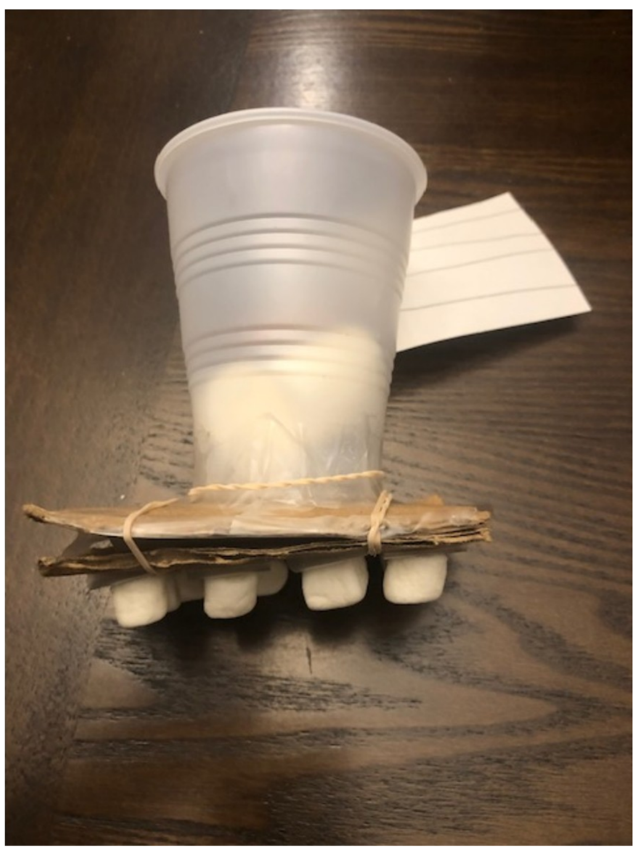


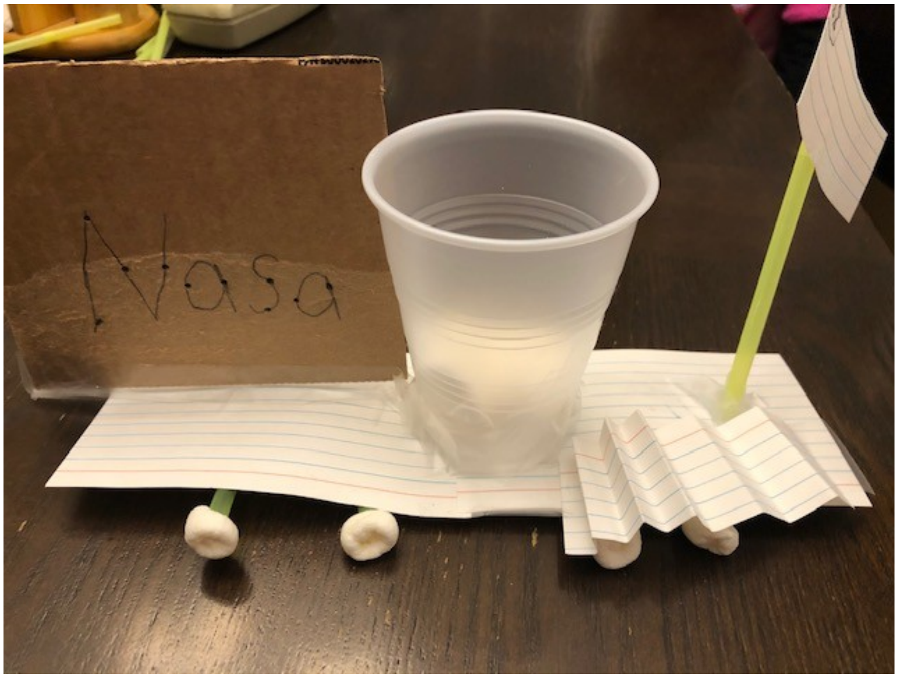

USA


Nasa









5. Test and Evaluate

The students were eager to test their spacecrafts. I explained that they should test from about the height of one foot (30 cm) and used a ruler to demonstrate this height. Students tested their spacecrafts as they worked to find things to improve. They were testing to see if their “astronaut” marshmallows landed safely and how high they could drop it from and still have a soft landing. I heard comments such as, “It works really great, but I just need a softer landing.” I asked questions to students so they could think about ways to improve their landing. I reminded the students that if the “astronauts” bounce out, they might need to figure out ways to improve their design. They should study the problems and redesign as needed.

Several students came to me and asked for help. I did not jump in and help right away. I sometimes gave them questions to ponder such as, “Do you think you could create a softer landing?” “Have you thought about the position of the cup?” “Can you add anything to the lander?” I provided some tips such as if the spacecraft tips over as it falls through the air, students should make sure it is level when they release it. They could also check that the cup is centered on the cardboard and that the weight is distributed evenly. Some students noticed that if they add soft pads or change the number or position of the shock absorbers, then this could make a difference. Some students also made the springs less springy so the astronauts did not bounce out.

The students kept testing over and over. They watched each other and did practice runs. I heard very supportive comments such as, “It is getting better each time.” “You are off to a good start!” “You are close.” This was great to hear!

6. Redesign

I feel like the students could have worked on this for hours or even days. I had to set a timer and it was helpful for this to be displayed for all to see. Students continued to make improvements and add details to their projects. They were proud of the new things they tried such as adding marshmallows to the bottom, changing the amount of weight, moving things around, and changing the size of the spring.

7. **Share the solution**

After the students had some time to make improvements, the students then showed each other their landers and talked about how they solved any problems that came up.   We measured how high they could drop from and used this as an opportunity to collect data to display the results. Students had fun trying the drop from various heights and trying to keep going higher. They also challenged themselves to see how many marshmallows would “survive.”

We then had a wonderful class discussion afterwards. I asked the following questions to lead this.

- What forces affected your lander as it fell?
- After testing, what changes did you make to your lander?
- Engineers’ early ideas rarely work out perfectly. How does testing help them improve a design?
- What did you learn from watching others test their landers?
- The moon is covered in a thick layer of fine dust. How might this be an advantage? A disadvantage?

Students also shared some things they would do differently next time and ideas they had such as they would add more cushion or springs at the bottom and they would check their rubber bands better. Students also thought they would move the cup to a different spot, put the flag they made in a different position, or change eh materials that they used. Students also commented that they got many good ideas from watching each other that they might try if they did this challenge again.

The students ended with a self-reflection. This focused on how they worked on the challenge as well as how their team worked together. They had to rate themselves and their team out of five stars. They also reflected on what went well and what improvements they could make next time.

Reflection

a) What went well with the engineering design challenge?

The engineering design challenge went well. The students were very engaged in the activity and did not want to stop working. They did a wonderful job coming up with ideas and creative ways to make their spacecrafts. They were excited to try new things and very motivated to succeed. Students were very supportive of each other and positive. I also liked that the students showed creative thinking and thought “out of the box.”

b) What did not go well with the engineering design challenge?

For the most part everything went well. I think next time I would be a little clearer on the directions regarding the cups. At first, the students were trying to close the cups by placing the index card on top. They also tried to restrain the marshmallows by squeezing the cup to make it tight against the marshmallows. I had to stop and explain to student that the goal is to try to design the spacecraft in which the lander does not fall over and that they would observe if the marshmallows could stay in the cup during the landing.

c) What concepts were covered (list standards and topics where appropriate)

The following standards were implemented in this activity:

Common Core Math Standards-Grade 3

CCSS.MATH.CONTENT.3.MD. A.1

Solve problems involving measurement and estimation.

National Council of Teachers of Mathematics Standards (Grades 3–8)

Problem Solving

- Build new mathematical knowledge through problem solving
- Solve problems that arise in mathematics and in other contexts
- Apply and adapt a variety of appropriate strategies to solve problems

Measurement

- Understand measurable attributes of objects and units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements

Next Generation Science Standards

3-PS2-1 Motion and Stability: Forces and Interactions

3-PS2 Motion and Stability: Forces and Interactions

4-PS3-3 Energy

ESS1.B: Earth and the Solar System

Massachusetts Science and Technology/Engineering Standards (Grades 3–8)

Physics (3–8)

- Observable Properties of Objects
- Position and Motion of Objects
- Properties of Objects and Materials
- Forms of Energy

Technology/Engineering (3–8)

• Materials and Tools

• Engineering Design

d) How did the engineering design process help teach the science and mathematics concepts?

The engineering design process was very helpful in teaching the science and mathematics concepts. Students made connections to real scientific concepts such as spacecrafts and astronauts. They also examined important science topics such as potential and kinetic energy when analyzing the shock absorbers that they created. They explored scientific ideas including acceleration and gravity as they experimented with their landers. They analyzed and observed topics such as air resistance. Students had the opportunity to do real-life problems solving. They identified the problem, considered the situation, materials, and constraints, and then worked to identify a solution. They practiced measurement as they measured the various heights form which they dropped the lander. They also collected data regarding their results.

e) Did I choose an appropriate engineering design process? Should I simplify or make more complex?

I think I chose an appropriate engineering design process for this age group. It was simple and easy for third grade students to understand each of the components. If this activity was done with older students, then a more complex engineering design process could have been used instead.

f) How can I improve this activity to use with future students?

I have several ideas for how to improve this activity in the future. I think it would be fun for the students to brainstorm different materials to use for this challenge. I also would probably allow more time. The students were so engaged in this activity that they did not want to stop. Unfortunately, due to schedules, I had to set a time limit for the amount of time they had for each of the steps. One student actually suggested testing the spacecrafts with an egg “astronaut” (perhaps outside) instead of the marshmallow “astronauts” when they felt very confident that their “astronauts” would not fall out.

References

Engineering Design Process. (2019). Retrieved October 10, 2019, from https://www.eie.org/eie-curriculum/engineering-design-process

[NBC News]. (2018, July 20). *160 Beats Per Minute: The Final, Frantic Moments Before the Historic Moon Landing.* [Video File]. Retrieved from https://www.youtube.com/watch?v=zplHIWNfR7Q

On the Moon Educator Guide. (2009). Retrieved September 1, 2019, from https://www.nasa.gov/stem-ed-resources/on-the-moon-guide.html

Appendix A-Touchdown Planning Sheet

Touchdown

Challenge- Design and build a shock-absorbing system that will protect two "astronauts" when they land.

Materials: (per lander)

- 1 piece of cardboard
- 1 small plastic cup
- 3 index cards
- 2 regular marshmallows
- 10 miniature marshmallows
- 3 rubber bands
- 8 plastic straws
- Scissors
- Tape

Brainstorm and Design:

Appendix B-Touchdown Reflection

Team Member Names: ________________ ________________ ________________

Reflection

We felt ______________ about our STEM activity today. We feel this way because

____

____

One thing that went well today was ____

____

One thing we need to improve on for next time is ____________________________

____

I give myself ☆ ☆ ☆ ☆ ☆ because _________________

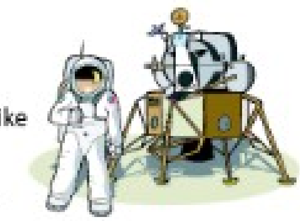
____.

I give my team ☆ ☆ ☆ ☆ ☆ because ________________

____.

Appendix C-Trip to the Moon Writing Activity

Creative Writing



Trip to the Moon

Imagine that you are travelling to the moon. Describe what it's like there and the things you did when you arrived.