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Engineering in STEM

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Major Project Phase II

Feel the Heat Engineering Project

1. Engineering Design Selected:

(https://www.nasa.gov/pdf/417998main_OTM_Feel_Heat.pdf)

2. Implementation Timeline

Day 1 -Identify the problem, Brainstorm	30 min
Day 2- Design, Build, Test, Evaluate	45min-1hour
Day 3- Redesign, Share and Solution	30 min

3. This design challenge was completed by:

Students in the after-school STEM club at Cottonwood Elementary in Holladay, Utah. There are 8 students in the club.

4. Engineering Notebook

1. Identify the problem

Day 1: I introduced the challenge to the students: In this challenge, kids follow the engineering design process to: (1) build a solar hot water heater; (2) test to see if it can raise the temperature of water; and (3) use their testing results to improve their heater and get as big a temperature change as possible. I showed the students an example water heater. We discussed how astronauts are returning to the moon to stay for a long time. They will need access to warm water. How will can we help astronauts build a solar power water heater?

2. Brainstorming

Day 1: We discussed the following questions:

1. How will a zig zag design with the plastic tube help the water flow?

2. How can we help the water flow out the tubes?

The students shared brainstorming ideas: some of the ideas included the following:

- using cardboard or a lid to a container to put the water tube
- use an orange cone to put the lamp on it
- use aluminum foil around the tube to conduct more heat
- use small potting cups to attach the tubes
- use a small ball pump to pump water through the tube

3. Design

Day 2: The students spent very little time designing their structure. I redirected them to design and discuss potential problems they may face during the building the stage.

4. Build

Day 2: Students began constructing their solar power water heater as one group. However, over time they decided to split into two groups. Eventually, the students had created two different designs. After awhile, they decided to come back as one group.

5. Test and Evaluate

Day 2: Before the students tested their prototype. We discussed how engineers make a lot of redesigns. We discussed how it was okay to fail or miss something the first time. We also discussed the purpose of testing something in order to fix problems before we use the real item in a real situation.

The students tested their design with regular water. They did not use a lamp to heat the water because they wanted to find out if the ball pump would help pump the water from one cup to another cup. They quickly realized they did not plug up leaks when they make the holes in the cups! They went back to the brainstorming phase to make adjustments and discuss redesigns.

6. Redesign

Day 3: They students plugged the holes and decided the ball pump in conjunction with the solar power made the water flow easier through the tube. They adjusted the height of the cardboard to make sure gravity was pulling the water downward.

7. Share and solution

Day 3: We discussed the engineering process and review the steps we took to reach a solution. We are still working on a design idea because the students did not want to stop at one solution to this challenge. It was excited to see their enthusiasm for engineering and science! I felt more comfortable than ever before teaching them an engineering design challenge.

5. Reflection

What went well with the engineering design challenge?

I decided to do this project with my after-school STEM club. There are eight students in the STEM Club. The smaller group helped me to observe the design process more precisely.

We started the Engineering process by identifying the problem and defining the purpose. The purpose: to build a solar power water heater for astronauts staying on the moon. This gave

them an authentic purpose to the design challenge. During the brainstorming phase, the students were very respectful and supportive with all ideas. The students liked the scenario of helping astronauts live and create a solar power water heater on the moon. During the brainstorming process, students would say, “the astronauts could do this…” or “I think we could do this for the astronauts…”

What did not go well with the engineering design challenge?

The students were very respectful, but they did not know how to problem solve as a team. They were able to revise and re-test, but they seemed to work more independently than together. The 8 students ended up splitting into a few smaller groups because they didn’t quite know how to share their ideas as a team. Initially, they did not spend a lot of time designing their project. They went from the brainstorming stage into the building stage. This slowed them down, because they were not able to troubleshoot or conceptually understand how to problem solve their designs prior to building it. I recommended to them to go back into the design phase in order to determine what materials they needed, and to make sure their ideas can be “turned into a realistic plan.”
(https://pbskids.org/designsquad/parentseducators/workshop/process_design.html)

Another problem occurred during the brainstorming and building phase. They were not able to eliminate all of there ideas. They were so enthusiastic about all the brainstorming ideas, they tried out each one without thinking about why it wouldn’t work.

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

I chose the lesson “Feel the Heat” (https://www.nasa.gov/pdf/417998main_OTM_Feel_Heat.pdf) This lesson targets Utah 6th grade science standards. The big idea is to use the engineering design

process to measure how much heat is transferred in a solar water heater design. Also, to test the water heater and improve upon its design. The following standards were covered:

Utah 6th Grade Science 6.2.4 standard:

Design an object, tool, or process that minimizes or maximizes heat transfer. (PS3.A, PS3.B, ETS1.A, ETS1.B, ETS1.C)

NGSS standard:

MS-PS1-6 Undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes*.

How did the ED process help teach the science and mathematics concepts?

Prior to this activity, we discussed the effect of heat from the sun. We also discussed renewable energy. The ED process helped students experience an authentic example of building a renewable item to use on the moon.

Did I choose an appropriate engineering design process?

Part of knowing if the engineering design process is appropriate comes from observing how engaged the students are during the process. Another piece of evidence knowing if it is appropriate is “asking does it target the standards and problem solving strategies?”

According to Kirkely (2003), part of problem solving is attitudinal. “To solve problems, learners have to want to do so, and they have to believe they can. Motivation and attitudinal aspects such as effort, confidence, anxiety, persistence and knowledge about self are

important to the problem solving process (Jonassen and Tessmer, 1996).The students were 99% engaged in this activity because this could actually be used on the moon.

The standards were met and targeted. However, I think there were some parts of this activity that were a little advanced for 6th grade. For example, they were not able to trouble shoot their design before they built the structure. This slowed them down because they kept making mistakes that could have been prevented with a through discussion of the design.

How can I improve this activity to use with future students? Should I simplify or make more complex?

Not only did this activity target 6th grade curriculum regarding heat transfer and how it affects water. But the actually assignment from your class was very informative regarding how I teach the engineering design. This assignment provided me experience teaching the engineering process and reflect on what I need to improve. For example, I will model the design process much more explicitly. Since the students didn't spend time drawing or discussing a design prior to building, they were not able to trouble shoot their prototype very well. Modeling the design process will help them spend more time discussing potential problems and how to solve them before stepping into the building phase. I would also like to explain declarative knowledge and procedural knowledge at a 6th grade level. I think this would help them understand problem solving more effectively.