

ENGINEERING NOTEBOOK

THE “E” IN STEM

Shaylee Rademacher

Phase I

Research and Planning – Shaylee Rademacher

1. The “Big” concept to be covered by this engineering design challenge is to learn to work through the engineering design process using an engineering notebook, by bundling content standards with engineering standards.
2. NGSS/MLS (Missouri Learning Standards)
 - Apply physics principles to design a solution that minimizes the force of an object during a collision and develop an evaluation of the solution.
 - Plan and conduct an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.
 - Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
 - 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.
3. Problem Solving
 - Students will work together to agree on the best solution to the problem. This isn’t always easy for middle schoolers, and is always a learning opportunity. Students almost always think their idea is the best. Learning that other people have valid, and sometimes better, ideas is a valuable life skill.
 - Students will have to create a space lander that meets the constraints of size, limited supplies, time, etc. Again, many middle schoolers want to drag their feet, mess around, and then hurry up and throw something together when the time limit draws near. Requiring a plan with a sketch that has to be approved prior to the “create” step will help students solve this problem. They always want to get right to the build.
 - Students will observe the drop of their lander, and can record it using slow-motion cameras on their phones. They can use the video to evaluate what happened to the design upon impact of the lander with the ground. This will help students to see where the structure is failing (astronauts/large marshmallows bouncing out of the Dixie cup) and decide how to fix the problem through the iterative nature of the design process.

Declarative knowledge

- Students will need to know that gravity pulls objects toward the center of the Earth (down, never up).
- Students will need to know that all things made of matter, have mass, and are affected by the force of gravity (Law of Universal Gravitation).
- Students will need to know that air exerts an upward force on objects that reduce the acceleration due to gravity.



- Students will need to understand that objects that are falling experience acceleration due to gravity.
- Students will need to know that acceleration can mean to speed up, slow down, or change directions.

Procedural Knowledge

- Students will need to know how to listen respectfully to everyone's ideas.
- Students will need to know what information should be recorded in the engineering notebook.
- Students will need to know the criteria/requirements/constraints for the project.
- Students will need to know that they cannot start the building/creating phase until they have an approved plan.
- Students will need to know how to work at a volume that is conducive to a productive classroom.
- Students will need to know how to “fail forward,” that failure is expected, and that their first idea may not work, and is usually the most common.

4. The ELA Missouri Learning Standards that will be addressed with this activity are:
 - Follow rules for collegial discussions and decision making, track progress toward specific goals and deadlines, and define individual roles as needed.
 - Delineate a speaker's argument and claims, evaluating reasoning in order to pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed.
 - Speak clearly, audibly, and to the point, using conventions of language as appropriate to task, purpose, and audience when presenting including appropriate volume at an understandable pace.
 - Position body to face the audience when speaking, and make eye contact with listeners at various intervals using effective gestures to communicate a clear viewpoint.
 - Plan and deliver appropriate presentations based on the task, audience, and purpose including multimedia components in presentations to clarify claims and findings and emphasize significant points.
5. The NASA Space Lander challenge is the activity I would like to do for this project.

I think the best activity to use to teach the given objectives is the NASA Space Lander challenge. When I was out of my classroom for a district meeting I had my students watch the NASA documentary called “The Mars Generation.” This video shows students 8th grade (just one year older than my students) through high school involved in a week-long space camp. They show the students going through the design process, and even talk about the need for research and design for landers on Mars. This is the perfect intro to this activity. I have done it for two years now, and the students love it. I'm using it again this year, but will introduce the more formal engineering design process along with the engineering notebook/journal.

Phase II

Implementation – Shaylee Rademacher

1. Select an engineering design process to be used in your class

I selected the Quest Engineering Design Process as the EDP that I would use in my classroom this year. I felt like the brief descriptions in each step would be beneficial in the 7th grade classroom. For example, in the “Ask” step there is a subtitle that says “Define the problem.” I thought this would help the 7th graders understand what they should be doing with that step of the process.

2. Develop an implementation timeline

An implementation timeline has been a challenging task for this project. We have had numerous unexpected and expected events that have taken us out of the classroom so the week of October 22 was the first time we had several days that we could dedicate to the engineering project. Students are still in the process of re-designing and testing. Only a couple of groups are ready to work on the presentation.

Day-to-Day Timeline

Friday before beginning the project – Put students into groups of 3. Give each student 3 sticky notes, and ask them to write down one question on each sticky note. Each question should be something they’d like to know about their partners, or something they’d like their partners to know about them. Examples – If you could go anywhere in the world for a vacation, where would it be? What is your idea of a perfect day? etc. All sticky notes are put in a stack, and they take turns being the celebrity for a celebrity interview. If there is a question they don’t feel comfortable answering they just say, “No comment,” and they move on. When each person has been the celebrity, they have the task of coming up with a team name. This activity does wonders to build a team spirit and camaraderie within the group.

Monday – Begin with video clip from the Design Squad – Morning message - Winston Churchill said this about failing...Success is not final, failure is not fatal: it is the courage to continue that counts. Lets' try to remember that the word fail means our "first attempt in learning." What have engineers done in the last 20 years that have changed the way we live?

Pose first question, “What is an engineer?” What have engineers done in the last 20 years that have changed the way we live?

Next - introduce the concept of the engineering design process by looking at several different EDPs. We discussed similarities and differences between two EDPs in their small groups (3 students) using a Venn diagram in the Engineering Design notebook, and then in a whole group discussion pointing out the over-riding iterative nature of the engineering design process. A failure is not fatal, but a first, maybe even a second or third, attempt to meet the challenge.

Tuesday – Students continue working through the engineering design notebook. The Space Lander Mission is included in the engineering notebook. Students are directed to read the mission and to define the problem. As soon as they have described the mission in their own words, they continue moving through the notebook, to imagine possible ways to reach the goal, brainstorming as many ideas as possible. Most students will be able to get as far as sketching their design in the plan stage. Before getting any supplies, each group is required to show me their labeled sketches for approval. After approval each group is allowed to collect their supplies and begin their mission.

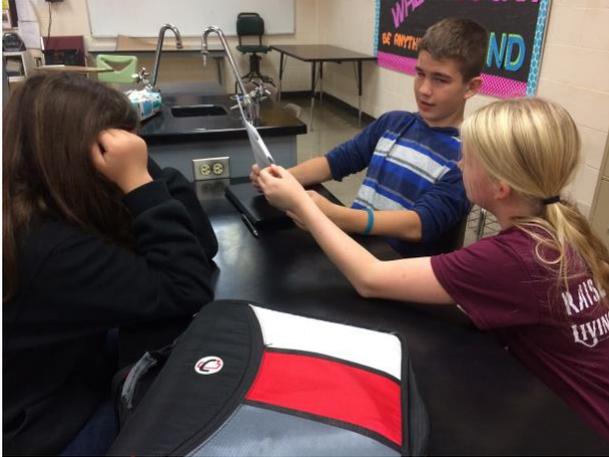
Wednesday – After approval and gathering supplies each group has two days to complete the building, testing, re-designing, and re-testing. Each group is expected to continue until they successfully complete the mission.

Thursday – Continue building, testing, and re-designing. If student complete the task successfully, then their group can continue onto the “share” step. They are to use a presentation platform of their choice to share their results with the class.

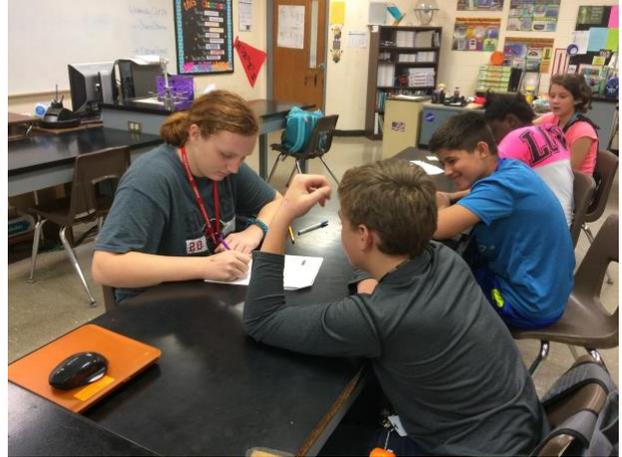
Friday – Continue working on their presentation getting ready to share on Monday

Monday – Each group will present to at least 3 other groups if time permits. Students will do peer assessments on each group that presents to them.

3. Perform the engineering design activity, either on your own or with your students.



Students beginning the first stages of the Space Lander Mission.



Students brainstorming ideas based on the mission details.

4. Complete an engineering design notebook.

5. Reflect upon your experience.

a. What went well with the engineering design challenge?

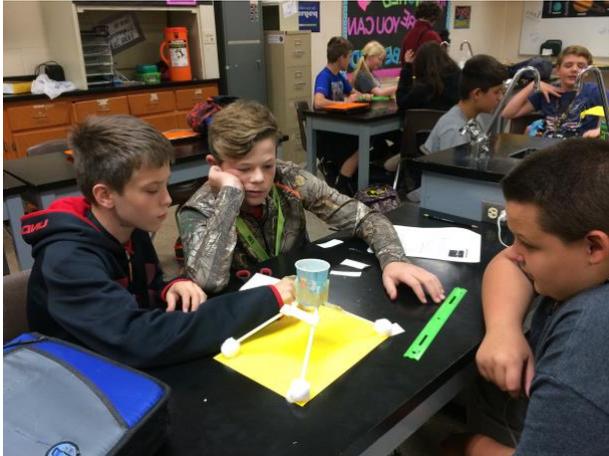
There were many things that have gone well with this design challenge. The first team building activity really helped turn the heterogeneous grouping into a team. Generally, when putting students into groups, unless they just happened to be put together with their friends, there is the usual awkward and uncomfortable feelings about being “stuck” in a group. The team building activity worked like a charm to break through some barriers to help build trust and a comfort level in the group.

Another thing that worked well for this project was the engineering design notebook. I have done engineering projects in the past without a notebook to guide students through the process. I have explained the process and encouraged the iterative process by telling students to keep trying if it doesn't work the first time. By using the notebook, it gave the students a step-by-step guide that led them from one step to the next, with little help from me. I do need to “tweak” a couple of things that I will discuss in the next section. The best thing about the engineering design notebook was the Plan stage where I provided a place for sketching out their idea.

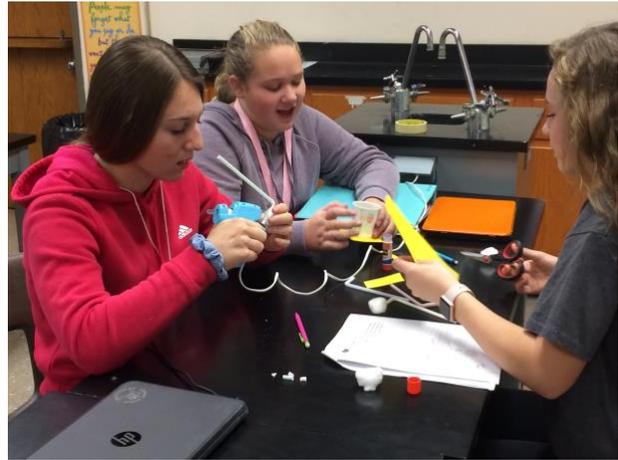


Students begin the construction/build phase.

I required this step (and all previous steps) before any of the groups could gather their supplies to begin constructing their prototype. This helped in two ways.



What do you think we should do? I don't know, what do you think?



Each team member has a job and is actively involved in the build.

One, the students had to slow down and think things through. They couldn't just jump into the building without talking things out with through group, listening to each other's ideas, and deciding on which design they felt would be the most likely to be successful. After they had a sketch that was labeled with the given supplies, then I allowed them to gather materials. The second way this step helped was to stagger the beginning building instead of all groups rushing to the materials at once with everyone at the same stage of the game, so to speak. This allowed me to coach groups at different stages, and made for a much more relaxed atmosphere for me throughout the activity.



More construction.



Testing (enthusiastically)

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

Honestly, not much. It was a great challenge. The students really enjoyed working with their teams, working through their failures, and celebrating their successes. I'm not sold on the Quest Engineering Design Process. I ended up spending a fair amount of time explaining to individual groups what was meant by Ask: Define the Problem. I think that I may develop my own model of the process with mini explanations that a 7th grader can understand. Another thing that I think I'll do in the future is to add sentence starters to the engineering design notebook. For example, for the Ask: Define the Problem step I could have a sentence starter such as...To complete this mission successfully we need to...

I will also make every effort to have no more than 3 students in a group. I ended up having 4-5 out of 43 groups with four students in the group. This was usually due to absences on the day the groups were set up. I've found that with middle schoolers groups of three is ideal, but I will go with groups of two before having a group of four. With four students, the arguing increases, one person generally doesn't have anything specific to do, so problems arise.

Finally, the Share part of the process is difficult with the large number of groups. Due to a time crunch I had the students present to other groups instead of presenting one at a time in front of the whole group. This makes grading the over-all project difficult for me. I have determined that the grade isn't the goal, and have tried to stress this "foreign concept" to the students, too.

c. What concepts were covered?

NGSS/MLS (Missouri Learning Standards)

- Apply physics principles to design a solution that minimizes the force of an object during a collision and develop an evaluation of the solution.
- Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
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- 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. How did the ED process help teach the science and mathematics concepts?

I have not used the ED process to specifically teach science and math concepts. We have studied the force of gravity, so the lander mission made sense to the students in relation to that. We have also discussed the future planned NASA mission to Mars, and the need for engineers and many other professions on that mission, so this project made sense as a stand-alone engineering project relating to the Mars mission. What I like about projects like this is the shared experience that I have with every single one of my students. When I talk about the project in the future, they will all have had the same

experience, and I can build on that with the science and math concepts. I recently talked with a past student of mine who is now a senior in high school. He said that he always remembered how I taught him how to calculate acceleration due to gravity, and “stuff about velocity.” Now he has a calculus class and they are working on calculating velocity and he remembers things he was taught in the 7th grade. He said he didn’t know why, but that had always stuck with him. That was awesome to me as a teacher, and I do know why it “stuck.” I’ve always done a lot of hands-on lab activity and those are the things that stick with you as a learner.

This challenge has helped build my students’ schema in relation to gravity, acceleration, forces, potential and kinetic energy, and Newton’s laws of motion. I can use this activity all the way through the year, and connect it with others, to help build my students’ understanding of physics and math concepts.

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

I feel that the Quest engineering design process wasn’t as easily understood as I thought it would be. It required a lot of clarification and explanation to the 7th graders. As stated before, I feel like I could develop my own model of the process, or at least write out what I would like and then look for one that more closely fits my needs.

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

I am currently taking the graduate course *Integrated Instruction and Assessment* through Adams State University. This class has focused on backward design and has truly helped me drill in on my focus for the Space Science unit that I teach. I have always struggled with pacing, as I am not a tested grade-level, so I don’t feel the push to rush through the material. I fill my unit with many types of instructional strategies and activities to reach different learning styles and abilities. My pacing struggles were amplified by unforeseen school closings due to area flooding. This made me realize that I need to do better with planning each day that I do have with the very most important activities. Doing so will help students to gain understanding and lead them to be able to transfer that understanding to different yet similar scenarios. Engineering projects take time, but are increasingly important in the STEM classroom. I want to be able to teach my curriculum and still have time for lengthy, but important, projects such as this.

I can improve this activity by making each step crystal clear for the students so they can work independently from one step to the next. It’s not that I don’t want to help them, but I feel that 7th graders are at the stage in their education where they still want the hand-holding security of the lower grades when they should be striving toward self-efficacy and independence.

I also wonder if I should allow students to fail more than I do. I had so many groups that didn’t keep the rules or parameters for this challenge in mind when they sketched their designs. If I had allowed

them to build without following my given rules and the group had to completely start over may have made more of an impact on them than me reminding them of the rules. I also have to balance the frustration level for the students, and the use of materials, as well. Overall, this project went very well. I will definitely use it again.

