

- I. Some Many Free Lessons from NASA You Can Use
- II. Curriculum Topics: Physics, Engineering, Engineering Design Process
 - a. School: Bennet Elementary School, Bennet, Nebraska
 - b. Number of Educators: 7
 - c. Grade Levels: Kindergarten, 2nd, 3rd, 4th, & 6th grades
 - d. Names and Contact Information:
 1. Gina Christensen: christensen.gin@districtor1.net * 2nd Grade
 2. Sadie Struebing: conn.sad@districtor1.net * 3rd Grade
 3. Nichole Ourada: ourada.nic@districtor1.net * 4th Grade
 4. Braston Maibaum: maibaum.bra@districtor1.net * 6th Grade
- III. Standards Addressed:
NGSS Standards-Ring Wing Glider
MS-ETS1 Engineering Design
 - a. MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
 - b. MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
 - c. MS-ETS1-4. 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.
3-5-ETS1 Engineering Design
 - a. 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
 - b. 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
 - c. 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
NGSS-Roving on the Moon
 - a. MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
 - b. MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
 - c. MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- IV. Summary of Project
 - a. Teachers experienced 3-D science, Next Generation Science Standards, the 5-E model, and the Engineering Design Process by working through two, free NASA JPL resources: Ring Wing Glider and Roving on the Moon.

V. Pre- Survey Questions List

Each response used a 5 point Likert scale—1 being a negative or unknown to 5--a superlative, expert self-rating. A rating of 3 is considered average.

1. How would you rate your knowledge level of the Next Generation Science Standards (NGSS)?
2. Have you heard of the 5-E lesson plan for science?
3. Have you ever used the 5-E lesson plan for science?
4. Have you ever used NASA's free on-line lesson plans?
5. Have you ever used the Engineering Design Process in a science class?
6. If you have used the Engineering Design Process, how often is it used in your class?

VI. Brief Description of the Actual Professional Development Training

The PD alternated between my PowerPoint presentation and two NASA activities-- Ring Wing Glider and Roving on the Moon. The second activity—Roving on the Moon—introduced participants to the Engineering Design Process along with the concepts from the first activity.

Part 1: Introduction of the PD-Why am I doing this? A requirement for my STEM Leadership Certificate/Master's Degree. This part of the presentation informed my colleagues about substantive changes that are driving science curriculum: A very quick history of the NGSS. What is NGSS? What is 3-D Science? What is the 5-E model?

Part 2: **Ring Wing Glider.**

Engage: Teachers watched short video of the Wright Brothers airplane flying in 1908. I discussed with the teachers how I had modified this project to gather data on the increasing mass of the glider and the distance the glider flies, which was done with my students earlier in the school year, versus altering the circumference of the glider and the distance flown.

Explore: The appropriate materials were passed out and gliders were constructed. Teachers lined to throw their gliders, mass was added in the form of paper clips or small binder clips. The masses of each paper clip were measured before the experiment began.

Explain: Teachers discussed how they thought lift occurred with the foil glider.

Elaborate: Teachers talked about how the airflow over an airplane wing creates lift and applied it to the foil design.

Evaluate: We discussed how the evaluation can be used formally or informally, formative or summative.

Part 3: PowerPoint slide showed the NGSS page for the standards that were met for this lesson, and how the lesson incorporated Discipline Core Ideas, Science and Engineering Practices, and Crosscutting Concepts, which made the lesson 3-D science.

Part 4: **Roving on the Moon:**

Engage: A link on the PowerPoint slide played a quick video of the real lunar rover.

Explore: The teachers were assigned the Roving on the Moon activity, and they gathered all necessary supplies. Teachers constructed their rovers and tested them out.

Explain: Of course, the rovers did not go very far in part because of their square wheels. Teachers hypothesized why.

Elaborate: Teachers talked about their own cars and what makes them travel smoothly.

Evaluate: We discussed how to use this portion of the activity as a formative assessment.

Part 5: The Engineering Design Process: Another slide presented teachers with an Engineering Design Process flow chart that I used with my 5th grade class. Teachers collaborated with others to redesign their rovers, so it would travel at least three feet and in a straight line; the same criteria used with my 5th graders. Teachers feverishly worked on their redesigns as I encouraged them to take notes and draw sketches of their new designs. There were plenty of questions just like the 5th graders had. We talked about reducing axle friction, form and function of wheels.

- VII. Brief outline of the activities in the professional development session
- a. The Ring Wing Glider activity allowed teachers to gather authentic data that they graphed and based their conclusions on the collected data. Teachers folded their gliders using the template provided by NASA JPL. Discussions ensued regarding the directions provided by NASA JPL and my modification to this lesson. Teachers were encouraged to modify any lessons as they saw fit to accommodate their students and to meet district and state standards. Teachers filled out data tables and graphed their results in two separate groups. We discussed what responsible conclusions could be drawn from the data, which precipitated a quick discussion regarding valid and invalid conclusions.
 - b. The Roving on the Moon activity asked teachers to construct a rubber band car, or lunar rover, that did not travel very far. Teachers were rather befuddled by the lack of travel in the rover. At this point, the Engineering Design Process was introduced, and we discussed what constitutes “well-defined” problem, “medium” defined problem, and an “ill-defined” problem. The rover’s construction was the “well-defined” problem with the “medium” defined problem following afterwards with modifications to the rover. Teachers began discussing what problems needed to be addressed to make their rover travel three feet in a straight line.
- VIII. What NASA mission data or Endeavor resource did you include?
The Engineering Design Process lesson portion of the Roving on the Moon activity came from the “E” for Engineering in STEM course that I took during Summer 2019. Also, the concept of a “well-defined” problem, “medium” defined problem, and an “ill-defined” came from the same class.
- IX. Follow-up activities & post-survey questions
Each response used a 5 point Likert scale—1 being a negative response or unknown response to 5 a superlative, expert self-rating. A rating of 3 is considered average.
Post-Survey Questions (sent to the teachers upon completion of the PD)
1. To what degree did the presenter increase your understanding of the NGSS?
If you answered "no" to question 1, what could be changed to increase your understanding?

2. Did the presenter explain the 5-E lesson plan format in an easily understandable manner?
3. Would you feel comfortable enough to use the 5-E lesson plan format in future classes?
If "no", would you share why you wouldn't use the 5-E lesson plan?
4. Were the examples of 5-E lesson plans--Ring Wing Glider & Lunar Rover--sufficiently explained by the presenter?
5. Did working through a science lesson aid your understanding of the NGSS and the 5-E model?
6. Did the presenter clearly explain the Engineering Design Process and how it fits into a science curriculum?

Follow-up Activities

The day after the PD, teachers were sent an email with the links to NASA sites that have free science lessons that were mentioned in my PowerPoint presentation:

- [NASA Jet Propulsion Lab \(JPL\)](#)
- [NASA STEM Engagement](#)
- [NASA Best Activity Guide](#)
- [NASA & Kids Club](#)
- [NASA Design Squad](#)

Two weeks after the PD, teachers were sent another email asking them to reflect on the topics presented in the PD:

1. Please describe how you might change your science pedagogy based on the science PD you attended?
2. How would you envision NASA lesson plans being used in your future science curriculum?
3. What support would you need to increase your comfort level with 3-D science and the 5-E model?

X. Outcomes. Final Data Collection and Analysis (address each point below)

• Survey Results/Comment on the content included in the project.

The pre-PD questionnaire results were interesting because teacher knowledge of NGSS, the 5-E model, and the Engineering Design Process seemed to increase by grade level. The kindergarten teacher was not aware of the NGSS, whereas as 2nd, 3rd, 4th, and 6th grade teachers rated themselves with passing knowledge of the standards with scores of 2s and 3s. In the post-PD questionnaire, these ratings changed to 3 from kindergarten to 4s and 5s with the remaining teachers. I interpret the increase from pre- to post survey results attributed to the excitement of attending a PD that teachers deemed relevant to their pedagogy. No, I did not survey teachers about possible topics for this PD. The PD's topic was chosen from observations, conversations, and interactions I had with these teachers. These interactions could not be obtained by the administration because of their position. In my mind, when talking to a principal or superintendent, my thoughts invariably revolve around the notion "how honest I should be with an administrator" when my opinion is sought. I'm sure this is true for most how people who are in a superior/subordinate relationship.

• **Survey Results/Comment on the pedagogy in the project.**

In the post-survey questionnaire, 6 out of 7 teachers responded that my presentation was clearly layout and easily understood by them, they rated themselves gaining a better understanding of NGSS, 3-D science, 5-E model, and the Engineering Design Process. Most teachers responded with 5/5 rating with one 3/5. This was a change from the pre-PD questionnaire in which the majority rated their knowledge of these topics as low: four teachers rated their NGSS, 5-E model, and Engineering Design Process knowledge 1/5 and three upper elementary teachers rated themselves at 3/5. One possible interpretation for this change in ratings is that teachers believed they had gained a better understanding of these topics from a more dynamic presentation of the topics. My PD was not straight lecture and talking at the teachers.

The kindergarten teacher expressed her reluctance with using the 5-E model in her post-survey by stating, “Not yet. If I were to use it. I think I would like to talk about it some more.” This is a wonderfully honest statement. It’s great to hear truthful ideas presented at a PD, but afterwards when reality sets in, then the uncertainty of incorporating something new sets in. Her response helped me formulate follow-up questions to her and the other teachers particularly: “What support would you need to increase your comfort level with 3-D science and the 5-E model?” Most teachers responded with a call for help to increase their comfort level with using the 5-E Model. The 3rd grade teachers responded that they plan to use the 5-Model at the beginning of the next school year.

The variation in PowerPoint presentation—lecture—and activities allowed the teachers to intimately view the various elements of my PD: 3-D science, 5-Model, NGSS, and Engineering Design Process. Teachers were not just sitting for 90 minutes listening to me prattle on about the presented topics. They got to experience the standards and the concepts with their hands. They conversed with each other, laughed, and listened to me and my experiences when I had done these very activities with my students.

• **Was your professional development successful? Why or Why Not?**

I believe the PD was quite successful because I’ve watched these same teachers at other PDs given by our educational service unit experts and not ask the presenter a single question. However, during my PD, teachers were engaged, asking a plethora of questions about the activity or concept, how my students engaged with the lesson, how I modified lessons, asked questions about the 5-E model, 3-D science, how the lesson fit with the 3-D science paradigm, and so on. I was surprised and astonished by the level engagement with my colleagues because I thought they’d treat my PD like others. By the PD’s end, one colleague told me that she thought I should do all science PDs for our school. Wow!

• **How did this project relate to the readings? Cite two examples.**

I believe that my PD was successful as it was because I was viewed as an embedded expert teacher presenting relevant information that is targeted to the teachers of my school. This idea aligns with the reform model described in Lustick’s article (2011) in which I saw my fellow “teachers as individual learners” who are wanting to learn how to teach science better.

Conversely, the attending teachers didn’t view my role in this PD as a disconnected expert who had not been in a classroom for years (Lustick, 2011). These teachers have

seen my science classes engaged in science.

As Daugherty observed in her article, the combination of “hands-on activities, teacher collaboration, and instructor credibility” factor into the effectiveness of professional development (2009). Fortunately, I incorporated two out of the three criteria mentioned by Daugherty and the third criterion—instructor credibility—came from teachers seeing my science classes performing experiments or participating in activities as they walked their classes by the large Rec room windows that allows all passersby to gaze into the room that I regularly commandeer for science. Teachers have known that I’m a strong advocate for greater student engagement in science, and they have seen this advocacy in practice on a regular basis.

• **Will the teacher do these activities again?**

I would love to present this PD or a different science PD. I really enjoyed the energy and the rapport with my colleagues. Also, science is too important to relegate to the back of the curriculum line. Based on the results of the post-survey, teachers seemed appreciative and were thankful for the update to their science pedagogy knowledge base.

• **Reflection:**

My PD content was chosen because I am part of my school’s science curriculum committee tasked with selecting new science material for the district. Several teachers who attended my PD are on this committee with me. Through the course of sales meetings and conversations, it became evident that many of the established teachers were not aware of the NGSS, 3-D science, the 5-E model, or the Engineering Design Process. My PD was timely in its introduction to the mature teachers at my school and served as a reinforcement tool for the newer teachers who had experienced these topics in college but had not implemented them in the science curriculum.

I believe it is too early to see any substantive changes in grade level curricula, but I will continue to track the progress of change.

The follow-up questions that were sent to the participants two weeks after my PD indicate a strong willingness to engage in further professional development, but, for that to happen, the building principal and superintendent must change the school calendar to incorporate PLCs. The excitement of my PD is still with me so much so that I plan to approach the new superintendent with the proposal to implement PLCs so that elementary science teachers, as a cohort, can collaboratively research, brainstorm, and develop grade level science curriculum tailored to that grade level. I’m thrilled at the prospect of contributing to this drive to bring these wonderful changes to fruition in my school.

Just after my PD, the science committee met with the secondary and elementary principals to discuss our impressions of science vendors’ materials we had been reviewing. We suggested that we, as a district, take another year to reach that decision. I mentioned that there are websites with free high-quality science curricula, NASA being one, that our district could use instead of purchasing materials from a vendor. It was suggested that the money could be better spent on teacher training, substitutes for teachers to engage in Lesson Studies, cover the cost of materials, and professional development. The decision was made to delay purchasing new science curricula because the entire committee was supportive of my suggestion to the administration. I found this support by the other science teachers, particularly those who came to my PD, to be an expression of their desire to alter their science pedagogy and curriculum. The teachers’

desire to change is there. Now we need time and money to make necessary changes.

References:

Daugherty, J. L. (2009). Engineering Professional Development Design for Secondary School Teachers: A Multiple Case Study. *Journal of Technology Education*, 21(1), 10-24. doi:10.21061/jte.v21i1.a.1

Lustick, D. S. (2011). Experienced secondary science teachers' perceptions of effective professional development while pursuing National Board certification. *Teacher Development*, 15(2), 219-239. doi:10.1080/13664530.2011.571511

Next Generation Science Standards. (2019, December 20). Retrieved February 16, 2020, from <https://www.nextgenscience.org/>

Roving on the Moon Activity. (2020, January 29). Retrieved February 16, 2020, from <https://www.jpl.nasa.gov/edu/teach/activity/roving-on-the-moon/>

The Ring Wing Glider Activity. (2020, January 30). Retrieved February 16, 2020, from <https://www.jpl.nasa.gov/edu/teach/activity/ring-wing-glider/>