Lesson Research Proposal for Grade 5 science
For the lesson on November 7, 2017
Science Conference: "It's Go Time: Science for All"

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Our Ideals

When our students graduate from North Syracuse Central School District, we would like them to be able to work collaboratively with their peers to design, build, and test a variety of scientifically based models. Additionally, we would like our students to understand the importance of testing the models they create to evaluate their efficiency.

We believe collaboration is a powerful strategy to solve problems. We realize the interpersonal challenges inherent to collaboration especially when engineering design tasks are required. We want to equip our students with the collaboration skills that enable them to interact with their peers productively. Specifically, we aspire to teach our students how to listen actively, ask questions, offer comments including compliments, be open to ideas, share feelings of frustration or dissatisfaction as they occur, and speak respectfully to their team members. We want our students to take responsibility for mistakes, and work to fulfill their obligations to their teams. We believe our students need experiences that require perseverance. We want them to remain positive even when a problem seems insurmountable, and when their team struggles to find solutions.

We believe the following research lesson addresses both our long and short-term ideals for our fifth-grade students.

1. **Title of the Lesson: Lesson 5 Water Pump "Pump It Up"**

2. **Brief Description of the Lesson:**
Students will work in collaborative groups to attempt to solve the problem of getting water to where it is needed. They will be required to use a model of a pump that efficiently transports water to make it more accessible. The model includes a system of plastic tubes with a valve powered by the suction action of a syringe.

3. **Research Theme:** Our research theme relates to our ideals for our students. The materials they are using to develop the pump model are challenging to manipulate. The position of the valve, the connection of the tube to the syringe, and the manipulation of

the syringe to create a suction will be sources of error or failure points. These failure points will cause our students both engineering design complications and opportunities to experience productive struggle. We are interested in discovering how our students solve the unique engineering design problem using these materials with minimal teacher direction. **Will they complete the first task, which is to build a pump system to move water? Once they build the pump, will the pump actually move water? How many of the teams will be able to complete all four tasks involved in this lesson? Will they be able to identify failure points on their own and write them in their notebooks?**

We intentionally constructed the lesson to minimize teacher directions. We would like to experience how productive struggle manifests in our lesson. We believe productive struggle has the potential to build our students' deeper conceptual learning. We want to collect data on how our students react to engineering design failure points and how this affects their collaborative experience. Students may need to manage interpersonal conflicts as they participate in collective problem-solving. In this way, we believe we are fostering student authority and agency. We want our students to feel empowered to employ their ideas to solve a problem and experience the consequences of their decisions. Our students will need to practice perseverance to complete the various tasks involved in this lesson successfully. **How will our students react to limited direction from the instructor? What does struggle look like and sound like in this lesson? Is there evidence of productive struggle, or failing better?**

4**. Goals of the Unit:**

As articulated in the Draft Teacher Guide for the Smithsonian Science in the Classroom unit titled, "How can we provide freshwater to those in need?"

a. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
b. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
c. Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and the environment.
d. Define a simple design problem reflecting a need or a want that includes a specified criteria for success and constraints on materials, time or cost.
e. 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.

f. 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.
g. Understand the major sources of water on Earth as well as water scarcity, issues with getting water to where it is needed, and how humans have dealt with these issues.

5. **Goals of the lesson:**
- Define criteria and constraints of the accessing groundwater problem
- Conduct fair tests and look for failure points in students' own design and the designs of their classmates as they seek to improve upon their original design.

6. **Relationship of the Unit to the Standards**

Related prior learning standards	**Learning standards for this unit**	**Related later learning standards**
4th grade Earth and Human Activity 4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural earth processes on humans. Earth's Systems 4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features.	5th grade Earth and Human Activity 5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment Earth Systems 5-ESS2-2: Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. 3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints in material,	Middle School MSESS-2 : Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. MSESS-3-1: Construct a scientific explanation based on evidence for how the unseen distributions of Earth's mineral energy, and groundwater resources are the result of past and current geoscience processes. MSESS-3-4: Construct an argument supported by evidenced for how increases in human population and per capita consumption of natural resources impact Earth's

	time, or cost. 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. 3-5-ETS1-3: Plan and carry out fair tests in which variable are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	systems. MS-ETS1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. 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.

7. **Background and Rationale:**

Students started this unit by investigating the question: Where does the water you need come from? The first four lessons in the unit allowed students to construct an understanding of where water was found on Earth, the distribution of freshwater, and the difficulty of getting water to where it is needed.The second part of the unit, in which the research lesson is the first in a four lesson sequence, students will investigate the question: How have humans impacted the water we need? Students will work on designing and comparing different designs that model how to bring groundwater to the surface. Additionally, students will work to understand how Earth's four spheres interact.

Lesson 5 (the Research Lesson) is important because it focuses the students on defining the criteria and constraints of a problem and then to test to see which aspects of their design help them meet the criteria. One way of doing this is a fair test. A fair test isolates one variable to test the effect of changing it and controls all other variables as best as possible. The variable the students will change in this lesson is the position of the pump (top or bottom). During the testing, students will identify potential failure points that may negatively impact the results of the test.

This lesson is important because it will help students understand the difficulty of moving water to where it is needed. This will build on early lessons which helped students understand water scarcity. This lesson is important for future learning in the unit as students will have to apply their learning from this lesson in the unit culminating design challenge. The final design challenge asks students to develop a water use and allocation plan and design for a town. In this design, students will have a budget and be asked to develop the best design they can. Students will have to use learning from all the previous design challenges in the unit to make a system design within the constraints.

This unit is based on the NGSS. The NGSS link to the *Framework for K-12 Science Education*, which was released in 2011 and used as the research basis for the new standards. A summary of the development of the *Framework*, as well as a link to the document can be found here: http://www.nextgenscience.org/framework-k–12-science-education.

As articulated in the *Framework* and put into practice in the NGSS, engineering needs to be a regular and coherent aspect of students learning during their K-12 experiences. These new standards really bring engineering to the forefront and this lesson and unit is an example of the thoughtful inclusion of engineering. Specifically the *Framework* and NGSS articulate the engineering design process (cycle between defining the problem developing solutions, and optimizing the design) because “From a teaching and learning point of view, it is the iterative cycle of design that offers the greatest potential for applying science knowledge in the classroom and engaging in engineering practices” (NRC, 2012, pp. 201-202). To support robust student learning instruction most thoughtfully integrate science concepts with engineering design. Students can not truly understand the engineering design process in isolation from developing conceptual understanding of science concepts.

A key aspect of the unit and lesson is students identifying constraints and failure points for a design. While children are natural builders, we need to be thoughtful in providing learning opportunities that help students deviate from impulse building, or building for building sake without a rationale. Children are natural builders but “children’s capabilities to design structures can then be enhanced by having them pay attention to points of failure and asking them to create and test redesigns” (NRC, 2012, p. 70). In the NGSS progression, students are expected to deepen their understanding of engineering design, build in the complexity of their design, engage in optimizing solutions in multiple iterations, and lead to their engagement in designing solutions to real-world complex problems. This unit and lesson are closely correlated with the real-world issues related to water quality and access.

8. **Research and Kyouzai kenkyuu**

The team focused on researching the principles of the engineering design process as articulated in the NGSS Appendix I. The team also focused on the disciplinary core idea progressions in the *Framework* for Earth’s Systems and Earth and Human Activity. This work helped the team understand expectations for 5th grade, as well as place the 5th grade expectations within the K-12 continuum. In considering this progression, we also took into account the fact that this was likely our students one of the first learning experiences designed around the new standards and the principles in the *Framework*.

We then reviewed the draft Smithsonian Science in the Classroom unit title: “How do we provide freshwater to those in need?”. This unit articulated the goals of the unit specifically tied to the NGSS. The unit brings to the center ideas related to engineering design. Specifically the unit allows students multiple opportunities to design solutions to various problems related to getting water to those in need. The unit asks students to identify design constraints and failure points. We noticed that the design increased in complexity throughout the unit. This led us to focus our work on lesson 5 in the middle of the unit to specifically focus on students designing a four-step solution.

The unit articulates the importance of helping students engage in thoughtful building. Specifically, the unit introduction cites research related to impulse building. We picked our research theme to focus on how our students collaborate in designing a solution and identifying failure points and using fair tests. We are hoping to learn more about student thinking to improve our design of learning tasks. This was of interest because the thoughtful design process included in this unit is different from traditional classroom design activities that usually only ask students to build one iteration without specifically discussing failure points, constraints, or criteria to determine the best design.

9. **Unit Plan**

The plan was developed from the Smithsonian Science in the Classroom's unit titled: "How do we get freshwater to those in need?"

Lessons 1-4 related to the driving question: Where does the water you need come from?. In these lessons students design ways to get water from one place to another and calculate their own water footprint.

Lessons 5-8 relate to the driving question: How have humans impacted the water we need? In this series of lessons, students investigate issues related to groundwater and getting ground water to the surface. Additionally, students develop an understand of various uses of water and the interactions of Earth's spheres.

Lessons 9-11 relates to the driving question: How have humans tried to solve the problems of getting freshwater to where it's needed? In this series of lessons, student investigate issues of water scarcity.

Lessons 12 and 13 center around: How can we provide fresh water to agriculture, industry, the environment, and housing in your town? In the final design challenge, students have to apply their learning from the various design challenges they solved earlier in the unit and incorporate issues related to drought and the needs of multiple stakeholders.

10. **Design of the Unit and Lesson**

This unit focuses on supporting all students developing an understanding of the engineering design process as well as science concepts. The unit is focused on students understanding contemporary issues related to water scarcity, specifically the availability of freshwater. Students' understandings of these issues should motivate the need for a water movement design that will effectively bring groundwater to the surface and will be challenged by the constraints and failure points embedded in the lesson.

As fifth graders, this unit is cognitively demanding because it is likely the first time that they have been challenged with a design problem so tightly coupled to a science phenomenon and limited by a series of realistic constraints. The research lesson is cognitively demanding because the materials they are using are new and they are being asked to solve a problem with limited directions for how to do so.

This lesson is accessible to learners because it balances individual student time to think and write with the group sharing of ideas. Students are working in groups of four so that there is opportunity to access the materials. As they design and test the water movement system, students get immediate feedback about the efficacy of their design.

Since students are being given wide latitude to test their design and share their thinking, they are engaging in practices that engineers engage in during their daily work.

Students' thinking will be visible through discussion, writing, materials use, and board practice. These mechanisms provide teachers with an opportunity to assess student learning.

11. **Research Lesson Plan**

Materials:

- 2 blue plastic buckets
- 5 lengths of clear tubing
- 1 valve
- 1 syringe
- 1 graduated cylinder
- 1 timer
- 4 connectors
- 1 set of four task cards per group

Introduction (10 minutes)

Whiteboard

1. Review general unit goal for students: How have humans impacted the water we need?
2. Teacher will review the process engineers use to solve problems, including defining the problem and the constraints of the problem. Students will be required to design and test their solutions.
3. Visual of groundwater/well
4. Visual of the entries in the science notebook from the previous day in regards to the focus question, constraints and procedure
    - Teacher reviews the Focus question and the problem that students need to solve. (Charts to refer to). How do we get ground water to those who need it in the most efficient way? (Move water from underground, pail on the floor, to the surface, pail on the top of the table.)
    - Task constraints: using all materials to set up a pump system, making only one change in the system; moving pump from top to bottom

- Discuss possible difficulties: tubing, valve position, syringe connections, inability to produce suction

5. Review the procedure of the lesson: Students will be made aware of the 4 tasks inherent to the engineering design of this lesson; Teacher indicates the four task procedure and asks students to tell in their own words what they will be doing.

Task # 1: Build pump system to move water
Task # 2: Pump is designed to move water
Task # 3: Measure the amount of water you can pump in 2 minutes with the pump at the top
Task # 4: Measure the among of water you can pump in 2 minutes with the pump at the bottom

Productive Struggle Procedure (25 minutes)
Procedure:
Materials will already be on the table, so when ready, students can begin Task 1, building the Pump System (green card).

1. Teacher will circulate among groups to monitor student progress, but will not offer guidance during the first part of the investigation. After 15 minutes, teacher will offer guiding type questions, or prompts to address misunderstandings of the materials or tasks. However, teacher will not provide direct instruction on how to solve the task.
2. As students complete each task, the teacher will give them the next task card, and they will proceed with that step.
    a. Task #2: Getting the Pump System to Move Water (orange card)
    b. Task #3: Measure the amount of water moved in 2 minutes with the syringe at the top. (yellow card)
    c. Task #4: Measure the amount of water moved in 2 minutes with the syringe at the bottom (blue card)
3. As students collect data on top and bottom pumps, they will enter it in their science notebook

Closing Questions (10 minutes)
Teacher facilitates discussion about what happened during the design task

1. What did you struggle with (failure points, sources of error, pressure of the syringe, fast versus slow suction, technique is important, leakage)
2. Why is it important to identify failure points ahead of time? (Valve)
3. Why is it important to identify failure points during the investigation?
4. Discuss their claims related to the focus question

5. If teams moved through the task, instructor will ask those teams to present their findings, or design solutions. Instructor will record their comments on whiteboard

12. **Evaluation**

	Emerging	Developing	Proficient
Collaboration	Students do not consider or apply relevant ideas heard during group discussion to optimize their plan.	Students consider some ideas and apply some relevant ideas heard during group discussion to optimize their plan.	Students consider all and apply relevant ideas heard during group discussion to optimize their plan.
System and System Models	Identifies a problem in someone else's argument	Identifies at least one problem in someone else's argument and provides a partial justification for why there is a problem	Identifies at least one problem in someone else's argument and provides a complete justification for why there is a problem

13. **Board Plan**

We plan to use the whiteboard to display the various phases of the lesson logically, and sequentially. We leveraged the whiteboard as a review of the concepts, and procedures discussed during the previous day's lesson. We used the whiteboard as a tool to review ideas, a place to post the focus question, and to record our students' thinking during the lesson. In the end, the whiteboard will be a historical record of our research lesson. When we introduce the lesson on November 7, we will provide observers with a sketch of our whiteboard.