Lesson Research Proposal for 5th Grade Water Treatment Design
For the lesson on November 8, 2016
Science Conference: “It’s Go Time: Seeing the future through the NEW NYS Science Learning Standards”
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1**. Title of Lesson:** The Clean Water Challenge

2. **Brief description of the lesson:** Students collaborate to design a three-step water treatment process that will decrease the levels of nitrates and improve water clarity.

3. **Research Theme:** How do 5th graders design a solution to a water pollution problem?

If provided a clear purpose, time to reason individually, and listen to ideas of friends, students can engage in the engineering design process to solve a problem.

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**

- Design a water treatment process based on given criteria and constraints.
- Compare and evaluate water treatment systems by engaging in evidence based argumentation.

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, 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.	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 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 lesson 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 last of a four-lesson sequence, students investigated the question: How have humans impacted the water we need? Students worked on designing and comparing different designs that model how to bring groundwater to the surface. Additionally, students worked to understand how Earth's four spheres interact.

Lesson 8 in the unit (the research lesson) focuses on students designing, testing, and evaluating a water treatment process. Water sources become contaminated from many sources, such as fertilizers from farming, particulates from erosion, and various chemical contamination from human activities. In this lesson, students will create a design solution to improve water clarity and decrease the nitrate concentration. The available materials will model real-life methods of filtration for particulate removal and chemical process to remove nitrates. Additionally, this lesson includes design constraints by limiting the materials available to student, which reflect a critical aspect of engineering design.

This lesson is important because it will help students understand the difficulty of water treatment. 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 units 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 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 8 in the middle of the unit to specifically focus on students designing a three-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 engage in designing a solution. In this lesson, the students are also asked to use measurement of water clarity and nitrate concentration before

and after treatment to compare the solutions. We are hoping to learn more about student thinking related to designing and comparing solutions to improve our design of learning task. This was of interest because the thoughtful design process include 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 lesson student 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 challenged 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 treatment design 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 without being given the 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. During the group discussion to identify criteria for judging how well their design works, students' ideas will be recorded on the board for all to see. Students are working in groups of three so that there is opportunity to access the materials. As the filtration system operates, 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**

In order to facilitate observers' note taking, the lesson plan is formatted differently and attached to this document.

12. **Evaluation**

	Emerging	Developing	Proficient
Argument Construction	Makes a claim and supports it with evidence or partial reasoning	Makes a claim and supports it with evidence and partial reasoning	Supports a claim with multiple pieces of evidence and clear reasoning
Argument Critique	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

	Getting It	Almost There	Got It
Argument Construction	Makes a claim and supports it with a piece of evidence **or** a general explanation	Makes a claim and supports it with a piece of evidence **and** a general explanation	Supports a claim with more than 1 piece of evidence **and** a specific and clear explanation
Argument Critique	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:**

Focus Question: How have humans impacted the water we need?

Engineering Task: Design a Small Water Treatment Surface System to clean water contaminated with soil and fertilizer

Constraints:

- Water treatment design must use only the materials provided:
    - Filters, charcoal, nitrate test strips, water clarity scale
- Water treatment design must have three steps

Criteria:

- Water treatment must decrease Nitrate and water clarity levels

Designs and results:

Group #	Before Nitrate : Water Quality:	Step 1	Step 2	Step 3	After Nitrate: Water Quality:
1					
2					
3					
4					
5					
6					