Middle School Lesson Title: *Human Impact - School Redesign*

Essential Questions: How does our school building impact the environment locally? How could people successfully monitor or minimize the impact of the students in our building? What limiting factors constrain success in monitoring or minimizing the impact of students in our building?

Summary: Students will identify issues within our school that affect the outside community or world. Students will be able to collect data on their school's impact on the environment utilizing interview data, surveys, activities, and other resources. Along with learning and using relevant scientific principles, students will be engineering a redesign of some aspect of the building to reduce some of our impacts. The local to global connections will be relevant to the UN Sustainable Development Goals (e.g. Goal #6 Clean Water and Sanitation, #7 Affordable and Clean Energy, #11 Sustainable Cities, #12 Responsible Consumption and Production, and #13 Climate Action)

Background:*Students will learn about the forces driving the water cycle prior to this series of lessons, then build upon the knowledge of how the use or conservation of fresh water within a building can contribute or relieve some of the issues affecting the larger community (as well as globally). Students will learn how energy for electricity is produced (renewable vs. non-renewable) and the various kinds of resources that are available and used up versus produced. Students will identify issues with resource availability in relation to energy use and consumption, as impacted by human population. Students will also identify issues with material use and waste as a result of human population and growth, specifically plastics, fabrics, paper products, and other recyclable material that they encounter on a daily basis. (Utilizing SENCER ideals http://sencer.net/sencer-ideals/)*

Problem Statement:

As students in (Name) Middle School, you've noticed some issues in our building. You are concerned about the amount of waste produced throughout the day, especially in the cafeteria, and the constant water wasting you see go on in the bathroom. Additionally, you started thinking about all the technology, lights, and heating/cooling used all year in our big building. With your team, you are to create a solution to one of these issues while considering the criteria and constraints. Your solution must be based on researched facts and the science principles we've been learning, and then add some creativity to make your initial designs better, more efficient, and work for our school. The solutions will be presented to school and district administration as possible changes to make in our building or other buildings in the future.

Grade Level: 6th

Time: for 10 lessons each 80 minutes, ~2 weeks with block schedule or ~4 weeks with 40 minute periods

Lesson Format/Structure: Template was adapted from the work of Moulding, et al. (2015) and BSCS 5E instructional model (Bybee et al. 2006)

Bybee, R., Taylor, J.A., Garner, A., Van Scotter, P., Carlson Powell, J., Westbrook, A. & Landes, N., 2006, The BSCS 5E Instructional Model" Origins and Effectiveness, Report prepared for the Office of Science Education, National Institutes of Health, 80 pp. Retrieved on 5/23/2018 at https://uteach.wiki.uml.edu/file/view/UTeach_5Es.pdf/355111234/UTeach_5Es.pdf

Moulding , B., Bybee , R. & Paulson, N., 2015*, A Vision and Plan for Science Teaching and Learning*, Essential Teaching and Learning PD, LLC, 180pp.

Additional Resource:

United Nations, 2015, Transforming our world: The 2030 Agenda for Sustainable Development (Resolution Adopted by the General Assembly on 25 September 2015 A/70/L.1; p. 35 pp.). https:/sdgs.un.org/2030agenda, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf?OpenElement

Student Learning Objectives: (include civic components)
Students will be able to:

- Identify a problem caused by human impact in our school that contributes to a larger problem within NJ and the globe (as defined by UN Sustainable Development Goals).
- explain the cause and effect of the human activity within our school and how it contributes to larger issues.
- identify criteria that must be met in order to solve the student-identified problem and constraints that limit the solution.
- conduct research of technology or techniques used in the past to address the problem, and evaluate them using student identified criteria.
- design a solution to monitor or minimize the human impact defined by the student-identified problem related to water conservation, energy use, or material waste.
- sketch or draft new solutions based on technologies or techniques from the past that fits into student identified criteria/constraints.

NGSS Performance Expectations:
MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
http://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/MS-ESS3-3%20Evidence%20Statements%20June%202015%20asterisks.pdf
MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

DCIôs
MS. ESS3.A Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.
HS.ESS3.A Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.
MS.ESS3.C Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth.
HS.ESS3.C Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. [Note: this lesson sequence was designed for middle school students; this HS standard was addressed in a modified way for younger learners.]

NGSS Components Addressed: The following elements of NGSS are addressed in each activity of the lesson, all of which will assist learners in developing proficiency in the associated performance expectations above.

Activity	Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Human Impact Activity #1	(6-8) Asking questions and defining problems; Analyzing data; Using	ESS3.C (6-8) Human activities have significantly altered the biosphere, sometimes damaging or	(6-8) Cause and Effect; Scale, Proportion, and Quantity;

	Mathematics and Computational Thinking	destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.	
	Blended 3-D Teacher & Student Actions: Teacher provides students with images and statements to identify the global issues from student guide slide show https://docs.google.com/presentation/d/1jCpu9Nqh66bvNoFsf3gz58cxDV9qdYqoQ689qbiTyvQ/edit?usp=sharing (slides 1-3). Prompt whole class discussion about lack of fresh water, material wastefulness, and energy consumption (in relation to the overuse of fossil fuels). Students will gather data about the topics within their own school using the data collection template https://docs.google.com/document/d/11owHH5STRb2NnPfMvy6At1vUDWffgg5WXSgskwLnYOc/edit?usp=sharing In small groups, students walk through school and surrounding areas outside as needed to view and collect data on what is available. Students come back to report out on the data they collected, as a whole group finish sharing and calculating data. Students explain what they think the problems within their school are that contribute to any of the 3 issues, summarize in-person research on slide 5 in student guide.		
	Connections Common Core Math & ELA: CCSS.MATH.CONTENT.6.SP.B.5.A Reporting the number of observations. CCSS.MATH.CONTENT.6.SP.B.5.B Describing the nature of the attribute under investigation, including how it was measured and its units of measurement. CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.		
Human Impact Activity #2	(6-8) Obtaining, evaluating, and communicating information	MS. ESS3.A Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes	(6-8) Stability and change; Energy and Matter: Flows, Cycles, and Conservation;
	Blended 3-D Teacher & Student Actions: Teacher introduces problem statement that incorporates both global and school issues (slide 4 in student guide) and connects to the project directions. Students identify any remaining questions about the school that they might need to know-conduct any remaining online research (water source, electricity sources in the state/town, waste disposal company and policies). Students rotate through centers conducting investigations, gathering information, making observations, and learning about science behind the problems and begin to discover solution options using the center packet: https://docs.google.com/document/d/1NCzHhfCbbxxYy4h4VcMjneaztEt0uJzZFyB0U--7D2s/edit?usp=sharing		

<table>
<tr><td></td><td colspan="3">After the centers, students will select which topic interests them most and they would like to try to solve. They will identify questions they are able to answer from the centers that will help them solve the problems, and questions that still are lingering (slide 6).</td></tr>
<tr><td></td><td colspan="3">Connections to Common Core:
CC Math & ELA:
CCSS.ELA-LITERACY.WHST.6-8.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
CCSS.ELA-LITERACY.WHST.6-8.8
Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.</td></tr>
<tr><td rowspan="3">Human Impact Activity #3</td><td>(6-8) Analyzing data; Asking Questions and defining problems; Obtaining, evaluating, and communicating information</td><td>(6-8) MS. ESS3.A Humans depend on Earth’s land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.
(9-12) HS-ESS3.A Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.</td><td>(6-8) Cause and Effect, Stability and change, Energy and Matter: Flows, Cycles, and Conservation</td></tr>
<tr><td colspan="3">Blended 3-D Teacher & Student Actions:
Teacher assists in forming student groups of 2 or 3, based on topic selection. As a group, students discuss and complete slide 7 & 8 simultaneously in the student guide. Teacher facilitates group work based on topic and models types of questions to ask-directing all students to focus on resource availability (freshwater, metals/plastics, and fossil fuels. Teacher asks questions: What happens to the freshwater supply when the number of humans on the planet increases? What happens to materials in the Earth when people make new stuff instead of reusing or recycling materials that have previously been extracted? If we continue to burn non-renewable energy sources like coal, natural gas, petroleum what will eventually happen?) Teacher helps connect student ideas to resource availability in an ecosystem through cross-cutting concept of stability and change, as well as energy and matter through food chains (population increase of organisms compared to resources such as water, shelter, food supply). In small groups, students discuss what science they need to learn in order to understand the problems and how to solve them. Students select the problem they would like to focus on, and identify what they need to understand about the issue to explain it and create a solution for it. Students will identify human activities in the school and world, and how they contribute to the problems identified in the school/world. Students conduct research or go through suggested activities to help them answer the questions they designed.</td></tr>
<tr><td colspan="3">Connections Common Core Math & ELA:
CCSS.ELA-LITERACY.RST.6-8.9</td></tr>
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	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. CCSS.ELA-LITERACY.WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. CCSS.ELA-LITERACY.RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.		
Human Impact Activity #4 (field trip)	(6-8) Developing and Using Models; Constructing Explanations and Designing Solutions	(9-12) ESS3.C: Human Impacts on Earth Systems Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation	(6-8) Cause and Effect Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)
	Blended 3-D Teacher & Student Actions: Teacher leads whole class discussion regarding full group project. Review directions of group project: https://docs.google.com/document/d/1v71V6s3oFnbS_5FF-RmNJDfydDqMeRYLkE3LFSr5OCI/edit?usp=sharing Teacher explains to students as a whole group, and in smaller groups students will create criteria and constraints for solving their selected problem (slide 9). They will focus in on one problem, and use the content to identify what science should be included when they provide their solution, teacher guidance and scaffolding will be important. in order to consider a reasonable solution that would minimize our schools impact (criteria), and what limiting factors we are restricted by (constraints). Students research, attend field trip, and present what has been done in other buildings to solve the issues they have been investigating. Students attending the trip to the LEED certified building will take tours, engage in activities, and record notes on how the facilities minimize it's impact on the environment. Students conduct independent or group research using template: https://docs.google.com/document/d/1ZdcRmggRV1TN_VCwwsesUB-VacurKBqltetfl2B9_Cs/edit?usp=sharing Students who attended the trip will turn key how the watershed building has addressed the 3 problems we started with → reduce the use of fossil fuels, conserve water, and reduce the amount of waste created in a day. Students present what they learned to their peers in small groups divided up by topic, students record "watershed research" in student guide slide show and add summarized online research (slide 10).		
	Connections Common Core Math & ELA: CCSS.ELA-LITERACY.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. CCSS.ELA-LITERACY.WHST.6-8.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.		

Human Impact Activity #5	(6-8) Analyzing data; Constructing Explanations and Designing Solutions;	(6-8) MS. ESS3.A Humans depend on Earth's land, ocean, atmosphere, and biosphere for different	(6-8) Cause and Effect, Energy and Matter: Flows, Cycles, and Conservation; Systems and System

	Obtaining, evaluating, and communicating information	resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes. (9-12) HS-ESS3.A Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.	Models; Structure and Function
	Blended 3-D Teacher & Student Actions: Using research of past practices (slide 10), students will work in groups to improve solution designs. Teacher facilitates by reviewing problem scenario, rubrics, project directions, and resources (links/slides) students should use. Students create draft in small groups and work on explanations. Students should explain how the solutions solve the problem in the school and scale it up towards solving the global issue. Students present drafts for feedback from peers and teacher on four categories: multiple solutions for the same problem, creativity compared to what already exists, explanation of the solutions and how they solve the problems, and presentation quality. Teacher provides informal and formal feedback to students individually and in groups, assess that each individual understands the concepts thus far. Students begin recognizing they will need math to prove their solutions will work.		
	Connections Common Core Math & ELA: CCSS.ELA-LITERACY.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. CCSS.ELA-LITERACY.WHST.6-8.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.		

Assessment(s) **(demonstrations of learning leading to performance expectations)**
Formative Assessments
Activity 1: Identify the problem our school contributes towards within the community/country/world- energy, water, or material waste **Activity 1: Collect and analyze data about the school in relation to the problems identified.** **Activity 2: Complete center activities to gather information about the science behind each issue** **Activity 3: Create a list of questions to guide scientific research/learning (need to know)** **Activity 3: Explain the scientific connections between the human impact issue and how it relates the environment or resource availability** **Activity 3: Describe the cause and effect of your problem and the impact on the environment, using**

evidence gathered from research **Activity 4: Identify criteria to meet, and constraints that limit your solution** **Activity 4: Evaluate technology or techniques of the past used to monitor or minimize the issues related to energy, water conservation, or material waste.** **Activity 5: Create a draft to show how your solutions would minimize or monitor the problem you are solving within the school and world.**
Summative Assessment
Final Project: Students design a solution to minimize or monitor the issues in the school as they relate to the larger problems in the community. They construct a 3-D model, poster, or written proposal to explain the solution.

Human Impact Activity 1: GLOBAL & SCHOOL IMPACT (80 mins)

Introduction *(include specific science content addressed in activity)*

Students identify issues in the world and collect data about their school to make connections to issues within the school.

Materials: computer/chrome books; Slide show with phenomena https://docs.google.com/presentation/d/1jCpu9Nqh66bvNoFsf3gz58cxDV9qdYqoQ689qbiTyvQ/edit?usp=sharing

Data collection worksheet:
https://docs.google.com/document/d/11owHH5STRb2NnPfMvy6At1vUDWffgg5WXSgskwLnYOc/edit?usp=sharing

Activity Sequence

(sequence which Includes identification of students prior learnings, student actions for demonstrating developing proficiency in NGSS components)

Student Prior Knowledge	Students should have a basic understanding of the carbon cycle, and that burning fuel releases carbon into the air. Students should understand that plants take in CO2 and release O2. Students should know about resource availability in ecosystems, what a resource is, and how population affects the amount of a resource available per organism.
Engagement (phenomena/ engineering scenario)	Show phenomena to students using slideshow (slides 1, 2, 3 - to identify the larger issues: lack of fresh water, material wastefulness, and energy consumption (in relation to the overuse of fossil fuels). Students should discuss in pairs and then whole group what the issues are that are pictured.
Gathering Data or Exploration	Ask students: Is there any way we can connect these global issues to issues in our school? What are the problems within our school regarding water conservation, material waste, or energy use? **Ask struggling students what they serve lunch on? Does it go in the garbage or is it reused daily? How much energy do think the school requires? How many classrooms with lights, heater, ac, computers, etc.?** In small groups- students discuss what policies or issues within our school contribute to those 3 issues. Share out and jot down class ideas. Break up students into groups of 3-4 to collect data about the school. Highlight the categories you would like each separate group to cover, and be sure to split up the work amongst the class. Students will gather data about the topics using a graphic organizer. https://docs.google.com/document/d/11owHH5STRb2NnPfMvy6At1vUDWffgg5WXSgskwLnYOc/edit?usp=sharing **Small group walk-throughs** Students will walk through the school and surrounding areas outside as needed to view what is available (note streetlamps have solar panels and on google Earth our building has solar panels), how many lights are on in a given time, notice motion sensors in hallways, check out garbage during breakfast and lunch, what is thrown out that could be recycled or reused- may need to research, what is the custodian and cafeteria staff's use of water, how about student use of water, etc.)
Reasoning or Explanation/ Elaboration	Share out as a class what we found out, and what questions we still have. Summarize information in slide 5 with key points that cover each topic. Identify who we need to ask or survey to figure out how we contribute to the problems.Ask students: What professionals can help us understand how our actions are affecting water conservation, waste, and energy conservation in our school? What is our water source? Where does our electricity coming from? What is used to produce it? Where does our

	garbage go when it is gone? As a class or in small groups, students conduct research to answer questions they don't know the answers to.
Reflection or Evaluation	Tell students they will be engineers trying to solve these issues, and play short video to introduce what engineers do. https://education.nationalgeographic.org/resource/nasa-kids-intro-engineering/ Suggested Homework: Students complete a water use survey at home to begin thinking about their personal use of fresh water. https://water.usgs.gov/edu/activity-percapita.html

Human Impact Activity 2: Scientific Principles (160 mins)

Introduction *(include specific science content addressed in activity) Students will visually see transfer of energy, identify renewable vs nonrenewable energy sources, understand how water moves into the Earth through the ground, sources of freshwater, types of waste materials, what happens to waste material, and what material can be reused.*

Materials: soda bottles cut in half, water, food coloring, filter paper, solar outdoor light, assortment of waste items from various categories

Centers worksheet: https://docs.google.com/document/d/1NCzHhfCbbxxYy4h4VcMjneaztEt0uJzZFyB0U--7D2s/edit?usp=sharing

Activity Sequence

(sequence which Includes identification of students prior learnings, student actions for demonstrating developing proficiency in NGSS components)

Student Prior Knowledge	Students should understand the context of the global problems, and begin to connect to the local/within school problems.
Engagement (phenomena/ engineering scenario)	Students read the problem scenario (slide 4) and identify their role in the problem, where the problem is taking place, and what the problems are. https://docs.google.com/presentation/d/1jCpu9Nqh66bvNoFsf3gz58cxDV9qdYqoQ689qbiTyvQ/edit?usp=sharing
Gathering Data or Exploration	Play video about engineering & engineering design process. https://www.youtube.com/watch?v=75okexRzWMk https://www.youtube.com/watch?v=fxJWin195kU Explain to students they will go through the engineering process to solve one of the 3 problems in our school or world. Provide project directions and identify the final project goal (to redesign one aspect of the school to solve one of these 3 issues we contribute towards). https://docs.google.com/document/d/1v71V6s3oFnbS_5FF-RmNJDfydDqMeRYLkE3LFSr5OCI/edit?usp=sharing Think-Pair-Share: What do you need to know about or learn in order to solve these problems? Think about questions you need to ask or surveys you may need to figure out the impact we have. Ask students prompting questions and break down the big ideas into freshwater resources, renewable and nonrenewable resources, and types of material waste. Students will be organized into small group instruction centers or stations to learn about their content of choice first, and then be exposed to others as well. **Station Model- Topic 1 Student Lead, Topic 2 and 3 Teacher assistance** Topic 1: **Energy flows and matter cycles within and among Earth's systems** Energy Activities: Students will look at an outdoor solar light (broken apart) using a guide, they will identify the source of energy for this and trace the sources of energy, then students will investigate renewable and nonrenewable sources of energy weighing out the pro's and con's of the various possibilities. Topic 2: **Most of Earth's water is in the ocean and much of the Earth's freshwater is in glaciers or underground.** Students will read about fresh water sources, learn about aquifers, porosity and permeability in a demo. Topic 3: **Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits**. Material Waste Activities: Students will research the various kinds of waste and where it goes- what can be recycled vs. not. Conduct sorting activity and describe the possible journey's for a plastic bottle.

	https://docs.google.com/document/d/1NCzHhfCbbxxYy4h4VcMjneaztEt0uJzZFyB0U--7D2s/edit?usp=sharing
Reasoning or Explanation/ Elaboration	After completing centers students select which topic they would like to focus on, teacher groups students into 3 large groups based on topic. Using center work, have students include questions they needed to answer that will be helpful for them solving the problem they selected. Students should try to generate at least 2 of their own questions that still remain to slide 6. Teacher should organize students into smaller groups based on the same topic selection, and similar questions.
Reflection or Evaluation	Students share questions with peers, and in pairs help each other find the answers to the 2 student generated questions. Share one question with whole class and the answer you researched. Students are challenged to do the “trash stash” activity over the next week. https://www.dosomething.org/us/campaigns/trash-stash

Human Impact Activity 3: Human Activities (80-110 minutes)

Introduction *(include specific science content addressed in activity) Students explain how human activities affect the environment through actions within their own school and actions around the world.*

Materials computers/chrome books

Activity Sequence

(sequence which Includes identification of students prior learnings, student actions for demonstrating developing proficiency in NGSS components)

Student Prior Knowledge	Students should have a basic understanding of resource availability in regards to freshwater, nonrenewable energy sources, and materials for producing plastics, metals, fabrics, etc.
Engagement (phenomena/ engineering scenario)	Take ecological footprint survey: https://islandwood.org/footprint-calculator/ Reflect on survey and "trash stash" activity through whole class discussion. Students review the global problem and school problem scenario for their topic within their project groups developed last class (groups of 2-3).
Gathering Data or Exploration	In small groups, students will discuss the problem they are going to address and explain the human activities and results that contribute to the issues in the world and school on slide 7 using the questions they identified on slide 6. Students will use their center work to help complete these slides, and complete independent research based on student generated questions as needed. Teachers will guide students towards the anticipated DCI's that will be the main scientific ideas to address, and provide suggested online resources such as videos, activities, and readings in a "flipped-style" classroom. Suggested activities/ resources by topic: Energy- Video: https://ny.pbslearningmedia.org/resource/8de53beb-c5a1-423b-b17e-f2efa4d6f01c/what-are-our-energy-choices/ Activity: https://concord.org/stem-resources/what-are-our-energy-choices (activity 1, 4, 5) Water- Video: https://www.voanews.com/a/shortage-fresh-water-threatens-become-global-crisis/2998113.html Activity: https://concord.org/stem-resources/will-there-be-enough-fresh-water (Activity 1,2, part of 5) Waste- Video: https://www.youtube.com/watch?v=mA608GJ-EzM Reading: http://www.wm.com/thinkgreen/what-can-i-recycle.jsp & http://greenliving.lovetoknow.com/How_Does_Recycling_Affect_the_Environment
Reasoning or Explanation/ Elaboration	Students complete slide 7 & 8 individually on their slideshow while working in small groups gathering data. When a group has completed slide 8, they will check in with their teacher for feedback and then be directed to share with a different group.
Reflection or Evaluation	Jigsaw and explain the human activities and results to a person with a different topic (energy shares to waste, waste to water, and water to energy). Students will reflect on their problems aloud and begin brainstorming possible solutions.

Human Impact Activity 4: Past Practices (80-120 mins)

Introduction *(include specific science content addressed in activity) Students will learn about a local Platinum LEED certified facility and how they have been minimizing their impact on the environment. Students will learn about other technologies that people have used or are currently using to minimize their impact.*

Materials computer/ chromebooks

Activity Sequence

(sequence which Includes identification of students prior learnings, student actions for demonstrating developing proficiency in NGSS components)

Student Prior Knowledge	Students should understand the problem they are solving and the human activities that cause it. Students should have an idea of what steps have been taken to try and solve some of these issues, and how resources can run out if not conserved.
Engagement (phenomena/ engineering scenario)	View engineering design process graphic. Teacher identifies what steps have been accomplished and what is forthcoming, introduce the idea of criteria and constraints show video to highlight this part of the process and pause when needed. https://www.youtube.com/watch?v=MAhpfFt_mWM Teacher leads whole class discussion regarding full group project. Review directions of group project as needed to create criteria and constraints for solving their selected problem (slide 9). Students will focus in on one problem, and use the content to identify what science should be included when they provide their solution, teacher guidance and scaffolding will be important. in order to consider a reasonable solution that would minimize our schools impact (criteria), and what limiting factors we are restricted by (constraints).https://docs.google.com/document/d/1v71V6s3oFnbS_5FF-RmNJDfydDqMeRYLkE3LFSr5OCI/edit?usp=sharing Use project options to guide criteria, remind students they need to mathematically prove their solution will work, focus on multiple solutions to the same problem, creativity (it can't be exactly the same as what already exists), and explanation must show how solutions solve the problem. Constraints should focus on time, materials, budgets, resources, accessible information, etc.
Gathering Data or Exploration	Students research, attend field trip (to Stony Brook Millstone Watershed's Platinum LEED certified facility), and present what has been done in other buildings to solve the issues they have been investigating. Students attending the trip to the LEED certified building will take tours, engage in activities, and record notes on how the facilities minimize it's impact on the environment. Show pictures of facility from trip (or using online resource from sustainability trail: **https://thewatershed.org/leed/** Students who attended the trip will present what they learned to their peers in small groups divided up by topic, and turn key how the watershed building has addressed the 3 problems we started with → reduce the use of fossil fuels, conserve water, and reduce the amount of waste created in a day. Students record "watershed research" in student guide slide show and add summarized online research (slide 10). Encourage students to learn about additional past practices, or dive deeper into the explanations of how these solutions work. (*if possible try and get guest speakers to discuss composting, solar energy or other forms of renewable energy, water facilities and filtration, bathroom technologies, etc.) Students conduct independent or group research using template: https://docs.google.com/document/d/1ZdcRmqgRV1TN_VCwwsesUB-VacurKBqltetfl2B9_Cs/edit?usp=sharing

Reasoning or Explanation/ Elaboration	In small groups, students explain which past practices they would like to utilize and improve for their project solution. Students should select 3-4 ideas they can build upon. Remind students they cannot use what already exists to solve the problem, but rather they need to find a way to revise it to be more effective, or better suited for our school. Students may think about policy changes, who will help implement, cost advantages and disadvantages, etc.
Reflection or Evaluation	Groups share out which project option they would like to move forward with (3-D model, poster/illustration, or written proposal). They should create a “Gots” and “needs” list to identify materials, actions, and knowledge they “got” or understand, and what they “need” or need help with. They should draft their own ideas at home, so they can discuss and make a draft as a group next class.

Human Impact Activity 5: Draft

Introduction *(include specific science content addressed in activity)*
Materials computer/chrome books
Activity Sequence
(sequence which Includes identification of students prior learnings, student actions for demonstrating developing proficiency in NGSS components)

Student Prior Knowledge	Students should understand the human activities that cause the issues in the world and the school. They should have a good understanding of how past practices have attempted to solve these issues, and how those solutions work.
Engagement (phenomena/ engineering scenario)	Ask students what makes a "good" model? Review student generated list of good model criteria such as: it explains something, labeled, organized in an order, easy to understand, has images and words, shows how something works, etc.
Gathering Data or Exploration	View criteria and constraints (slide 9), revisit problem scenario & project directions as needed. View past projects or a teacher model of a project, evaluate what to look for and what is potentially missing. Students work in small groups creating their model's draft. Teacher meets with groups and checks for understanding from each individual, encourage students to ask questions of peers if there is anything they are unsure about. Tell students this is a checkpoint where every group member should be able to independently explain what is going in your project, the problem, and solutions. Remind students of their previous work and have them review their own slide shows for feedback.
Reasoning or Explanation/ Elaboration	After completing their drafts, provide students with evaluation criteria (rubrics) and go through reflection activity using their own work. https://docs.google.com/document/d/1U6VCZcLB-CgfY-IbjWlJKnlxalpJsVTIdktym_tnMHo/edit?usp=sharing Students present project to peers and teacher. Teacher models how to give constructive feedback to a peer (teacher demo), use scientific language stems or talk prompts to aid discussion (Where did you see that? How is your design different than what exists? Explain how this solves the problem in school and the world. How can you mathematically prove this will work?). Students present work to peers in the whole class for feedback. Students upload a copy of their draft into Slide 11 and create an individual explanation of how the solutions solve the problem in the school, and the world.
Reflection or Evaluation	Using feedback, and what you heard from your classmates, ask students: What revisions or additions will you make? What kinds of feedback was most helpful? Plan how to build, draw, or write up your project and gather materials. How will math be helpful in our engineering project? Play video to get ideas: https://www.youtube.com/watch?v=j3ctRmmHH7E Ask all students to review the data we collected about the school at the start of the unit. Students should circle the calculations relevant to their project. Students begin planning what kinds of math or experiment they can do prove their solutions will work when they compare it to the original numbers.

Note: A next iteration of this unit began with the ongoing issues in Flint as the centralized problem, and connected to the U. N. Sustainable Development Goals.

“Center” Worksheets

ENERGY CENTER

Deconstruct a solar powered light, and explore what is inside:

What sources of energy are involved?

What energy transformations are occurring through this light working?
→ → → →

Find the following answers on: https://www.eia.gov/KIDS/energy.cfm?page=1

Define Renewable Energy	
Define Nonrenewable energy	
Examples of non-renewable energy sources are:	
Examples of renewable energy sources are:	
What is the difference between energy conservation and energy efficiency?	Energy Conservation: Energy Efficiency:
What is the percent of energy used for education?	

WATER CENTER

Permeability: the ability of a substance to allow water to pass through (ex. A ceiling does not let water pass through it is impermeable and filter paper lets water pass through it is permeable)
Porosity:
Water Conservation:

Illustrate the space between the particles, record the time it takes to flow through, and the amount of water that passes through

Sand	**Soil**	**Rocks**
Time: **Amount of water: mL**	**Time:** **Amount of water: mL**	**Time:** **Amount of water: mL**

Research Task:

1. **Where is the majority of freshwater on Earth?**

2. **What issues to people have with having access to fresh water?**

3. **As human populations increase, what happens to our access to fresh water? Where is this a major issue?**

4. **How does understanding permeability and porosity relate to ground water?**

MATERIAL WASTE CENTER

Define the following:

Reusable Material:
Recyclable Material:
Compostable Material:

***Activity Directions*: Provided an assortment of items, sort the materials provided into the following categories. Record the names of the items in the chart below**

Recyclable Materials	Compostable Materials	Reusable Materials	Garbage

View video: https://www.youtube.com/watch?v=_6xlNyWPpB8 **Describe the 3 possible journey's the bottle can take.**

Human Impact Engineering Challenge

Problem Scenario: As students in (NAME) Middle School, you've noticed some issues in our building. You are concerned about the amount of waste produced throughout the day, especially in the cafeteria, and the constant water wasting you see go on in the bathroom. Additionally, you started thinking about all the technology, lights, and heating/cooling used all year in our big building. With your team, you are to create a solution to one of these issues while considering the criteria and constraints. Your solution must be based on researched facts, and then add some creativity to make those designs better, more efficient, and work for our school. The solutions will be presented to school and district administration as possible changes to make in our building or other buildings in the future.

Engineering Challenge

- Your **challenge** is to redesign one component of our school building or create a new process or policy to lessen the impact of our school on the environment.
- The pollution or issue you solve should be a real threat that exists in the community or global perspective.
- Your design, process, or policy should **REDUCE** the amount of energy, water, waste or materials we use, which in turn can **PREVENT** pollution from getting into the environment.
- If you choose to **REDESIGN** a part of the school, you must make a modification to it to make it **DIFFERENT** than what already exists in other places (including the watershed).
- If you choose to **DESIGN** a **NEW** process it should be unlike anything else you have already seen or experienced.

There will be pieces of the project collected along the way that will contribute to your marking period grade.

- **Individual Project Grade:** Slide show documenting the engineering process
- **Group Presentation & Product Grade:** Creating a 3-D model, poster/ illustration, or written proposal to explain your solution.

Record your choices below

Group Members	
Topic	
Project Option	

Topics and search terms to use to get started- pick one problem to address

Energy Use/ Use of Fossil Fuels	Water Conservation	Material Waste
● Carbon footprint	● Water usage	● Resource availability

• Air pollution from burning fossil fuels • Power plants or car emissions • Renewable or nonrenewable energy • Geothermal, wind power, solar power, nuclear, hydroelectric	• Fresh water storage • Droughts • Low-flow, flow restrictors • Availability of clean or fresh water • Water filtration issues • Overconsumption of water • Water wastefulness	• Where does garbage go? • Recycling versus garbage • Over consumption of materials

Essential Question	**Standard (PE or DCI)**	**Project Component**	**Point Value Break Down**	**Points Earned**
What evidence or tests can be used to prove the solution is effective?	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.	Slide 5: Summarize data collected about the school to develop a baseline of energy and water use, as well as waste production.	5	
How do humans affect resource availability of _____?	MS. ESS3.A Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.	Slide 6: Identify questions about the science behind the availability of resources (based on topic) and human activities causing depletion. Answer questions to explain the availability of natural resources and use of materials.	10	
How do humans affect resource availability of _____?	MS. ESS3.A Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.	Slide 7: Identify relationships between the human activity and the environmental impact based on scientific principles.	6	
How do humans impact the	MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a	Slide 8: Describe the human activities (in the world and globe) and the	4	

environment locally?	human impact on the environment	problem they contribute to in the world and scaled down to the school.		
How could people successfully monitor or minimize the impact of humans? What limiting factors constrain success in monitoring or minimizing the impact of humans?	MS-ETS1-1.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	Slide 9: Identify 5 criteria that must be met in order to solve the student-identified problem. Identify 3-5 relevant constraints that limit the solution.	10	
What technology was used to monitor or minimize the impact of humans in the past?	MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	Slide 10: Conduct research of technology or techniques used in the past to address the problem, and evaluate 2-4 of them using student identified criteria.	10	
How could people successfully monitor or minimize the impact of humans?	MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per capita consumption of natural resources impact Earth's systems MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment	Slide 11: Illustrate a solution to monitor or minimize the human impact defined by the student-identified problem. Explain how the solution will work to solve the problem in the school and the world based on technologies or techniques from the past that fits into student identified criteria/constraints.	10	
What evidence or tests can be used to prove the solution is effective?	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.	Conduct a test that simulates the real-life scenario or calculate mathematically to provide evidence that the design will be effective. Compare calculations to data originally collected about the school. Make	10	

		revisions to the design to prove effectiveness.		
What evidence or tests can be used to prove the solution is effective?	MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Write claim evidence reasoning proving multiple solutions will work using data calculated as evidence.	10	
How could people successfully monitor or minimize the impact of humans?	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	Create model (3-D, Illustrated, or written proposal) to effectively monitor or minimize the impact of humans on the environment in NJ.	10	
How could people successfully monitor or minimize the impact of humans?	MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	Evaluate peers solutions to problems based on their criteria and constraints. Explain whether or not classmates' projects were able to effectively meet their criteria by providing evidence.	5	
How could people successfully monitor or minimize the impact of humans?	MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Final project evaluated based on having multiple solutions, creativity, explanation, and clear presentation.	10	

School Data Collection

Energy	
# of Lights in Hallway_____ x number of hallways _____	
# of lights in classroom ___ x number of classroom rooms ___	
# of lights in bathroom _____ x number of bathrooms _____	
Total # of lights _____ x watts per bulb _____ (fluorescent) Total # of lights _____ x watts per bulb _____ (hallway- LED)	
# of outlets in classroom _____ x number of classrooms _____	
# of electronic devices in use in classroom _____ x number of classrooms 70	
# of (working) hand dryers in bathrooms _____ + _____ + _____ + _____	
What does the electricity bill show about our school's energy use?	
What does the electricity bill show about our school's energy production?	

Water	
# of toilets per bathroom ____ x number of bathrooms _____	toilets
# of sinks per bathroom _____ x number of bathrooms _____	sinks
# of water fountains _____	water fountains
How many flushes per day? On average a student flushes ____ times x _____number of students in school X 3 Gallons per flush	= gallons a day
How long does a sink run when pressed? __ minutes x average number of times students wash hands ___x _____students x 2.5 gallons of water	= gallons a day
How long does a water fountain run when pressed? __ minutes x average number of times ___ x ___students get water x 2.5 gallons of water	= gallons a day

Waste Material	
Sources of waste during breakfast & their masses in grams:	
# of recyclable materials from breakfast ___ x number of students that eat _____	_____ Recyclable materials _____ grams of recyclable materials
# of landfill materials from breakfast ___ x number of students that eat	_____ items going to landfill _____ grams of landfill materials
Sources of garbage during lunch & their masses in grams:	
# of recyclable materials from lunch___ x number of students that eat _____	_____Recyclable materials _____ grams of recyclable materials
# of waste materials from lunch ___ x ___number of students that eat	_____ waste items _____ grams of landfill materials
What items do you notice in the classroom recycling bin vs garbage bin?	
Amount of paper towel used per hand washing _____ x ____ students x ___ times a day drying their hands	_____ paper towels
Sheets of paper thrown in garbage vs recycling	

Data collection comparison

Original Data: Write equation, solve the problem, and explain what this shows about our school currently.	Testing Data: Write equation using your solution numbers, solve the problem, and explain what this shows about our school currently.
What conclusions can you draw from this comparison of numbers? Will your solution work? How can you prove it mathematically? Which equations were most convincing?	

Group Presentations Feedback Form

Write the names of the group members presenting and their problem scenario. Rate the categories with a score from 0-3 (0 not at all, 1 kind of meets criteria, 2 mostly meets criteria, and 3 totally meets criteria). Write down notes about their project you liked, or a piece of feedback for improvement. Add 1 point for a clear and understandable presentation, add up the total at the bottom.

Group:	Problem Scenario Topic: Human Activities: Results of Activities
Solution: Multiple Solutions to solve the same problem based on facts and research	Score: Notes/Feedback:
Creative: it's a modified version of what you've researched	Score: Notes/Feedback:
Explanation: Describe how this is actually solving the problem	Score: Notes/Feedback:
Total: ___ + ___ + ___ + ___=_____	

Group:	Problem Scenario Topic: Human Activities: Results of Activities
Solution: Multiple Solutions to solve the same problem based on facts and research	Score: Notes/Feedback:
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Explanation: Describe how this is actually solving the problem	Score: Notes/Feedback:
Total: ___ + ___ + ___ + ___=_____	

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Explanation: Describe how this is actually solving the problem	Score: Notes/Feedback:
Total: ___ + ___ + ___ + ___=________	

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Explanation: Describe how this is actually solving the problem	Score: Notes/Feedback:
Total: ___ + ___ + ___ + ___=_____	

Research of Current and Past Practices

Suggested Resources
http://www.usgbc.org/projects/ http://www.gen7schools.com/ http://www.usgbc.org/projects/stony-brook-millstone-watershed-associat

Evidence Source (website)	Evidence Quality Rating	Evidence Key Words	Identify the current technology they are using and how it solves the problem in our school.

At the time of submission of this document, a pared down version of this lesson sequence was being tested. For more information about these possibilities or any other aspect of the lesson sequence, contact Jessica Monaghan, jmonaghan@princeton.edu